STUDY OF VARIOUS COAL MINES
in
UTAH, COLORADO, AND WYOMING

by

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Approved by

This thesis is a record of the visits and first hand studies of various coal mines in the states of Utah, Colorado, and Wyoming

on

Mining Methods

by

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CHAPTER I

INTRODUCTION

In preparing this thesis, some of the prominent coal mines in the states of Utah, Wyoming and Colorado were visited. These included the Sunnyside, Castle Gate, Geneva Coal and Kenilworth mines in Utah; the D. O. Clark, Reliance, and Stansbury mines in Wyoming; and the Imperial and Eagle mines in Colorado.

The first part of the thesis contains descriptive information of each mine. This includes the stratigraphy and geology of the respective areas and also the mining methods and types of equipment employed underground. Also presented is a criticism of certain systems as used under the certain prevailing conditions.

The second part is mainly a comparison involving economics, safety, recovery percentage and the production rates of the mines. These are compared with a view to the methods being used underground. All of the mines studied have adopted the room-and-pillar method with the use of shaking conveyors, mobile loaders or a combination of the two. Therefore, the specific comparisons are based chiefly on the adaptability and productivity of the systems employed under the prevailing natural or physical conditions. However, the factors involved in comparing the mining methods are so complex and variable that ideal exactitude is difficult.

PART ONE

DESCRIPTION OF MINES

* * * *

CHAPTER II

SUNNYSIDE NO. 1 MINE

The Sunnyside No. 1 Mine, a property of Utah Fuel Company, is situated at Sunnyside, Utah, 150 miles southeast of Salt Lake City and 28 miles east of Price, Utah. Utah State Highway No. 123 passes through the town of Sunnyside.

The history of the mine dates back to 1900, and today it is one of the modern mines in the West. At present, it is employing an average of 110 men underground, and producing about 2,000 tons of coal per three-shift day.

Seam Characteristics and Geology.-- The rank of the Sunnyside coal is sub-bituminous, and it is of Upper Cretaceous age, Mesa Verde group. The coal measures, in this district, are composed of two seams, that is, the Upper and Lower Sunnyside seams. These two seams are separated by layers of interbedded sandstone and shale from 35 to 40-ft. in thickness. The upper seam, which ranges in thickness from 2 to 6-ft., is not mined. The Lower Sunnyside seam, which ranges in thickness from 6 to 14-ft., is being mined. In this seam there is a rock parting of from 15-in. to 6-ft. thick, mainly in Dip No. 2 sections, with the mineable coal underneath it. Toward the southeast the parting disappears, but the thickness of seam drops from 14 to 9-ft. This rock parting where not removed with the coal, forms a bad roof because of its poor cementation characteristics with coal.

In places where no parting is present, sandstone and hard shale make a fairly strong roof. The area is badly faulted (See mine layout map showing faults) in places and this has marked effect on the mining operation.

The coal is massive in structure, and shows little evidence of bedding. It has a low sulphur and ash content, and is good coking coal. The seam dips in a northeasterly direction at the rate of 16 percent near the outcrop and 10 percent at the inby end of the slopes.

Mine Layout.-- The mine is entered through a slope starting at the outcrop, on a dip of 12 percent. This slope entry connects with the Main North at a distance of 1,100-ft. from the outcrop. The Main North, which is driven on strike, consists of two entries, each 18-ft. wide and on 60-ft. centers. Fig. 1.

From Main North three sets of slope entries are driven off down the dip approximately at right angles to it. The set through which the mine is entered, is called the "Outside Slope." The other two are "Dip Slope 1 and 2." The distance between the Outside Slope and Dip Slope 1 is 5,400-ft. Dip Slope 2 is 2,400-ft. beyond Dip Slope 1.

Strike entries are driven at right angles off the dip slopes to the right and left at about 450-ft. intervals. These are 18-ft. wide and on 80-ft. centers. The system of mining, due to the geologic conditions, has varied. Some are

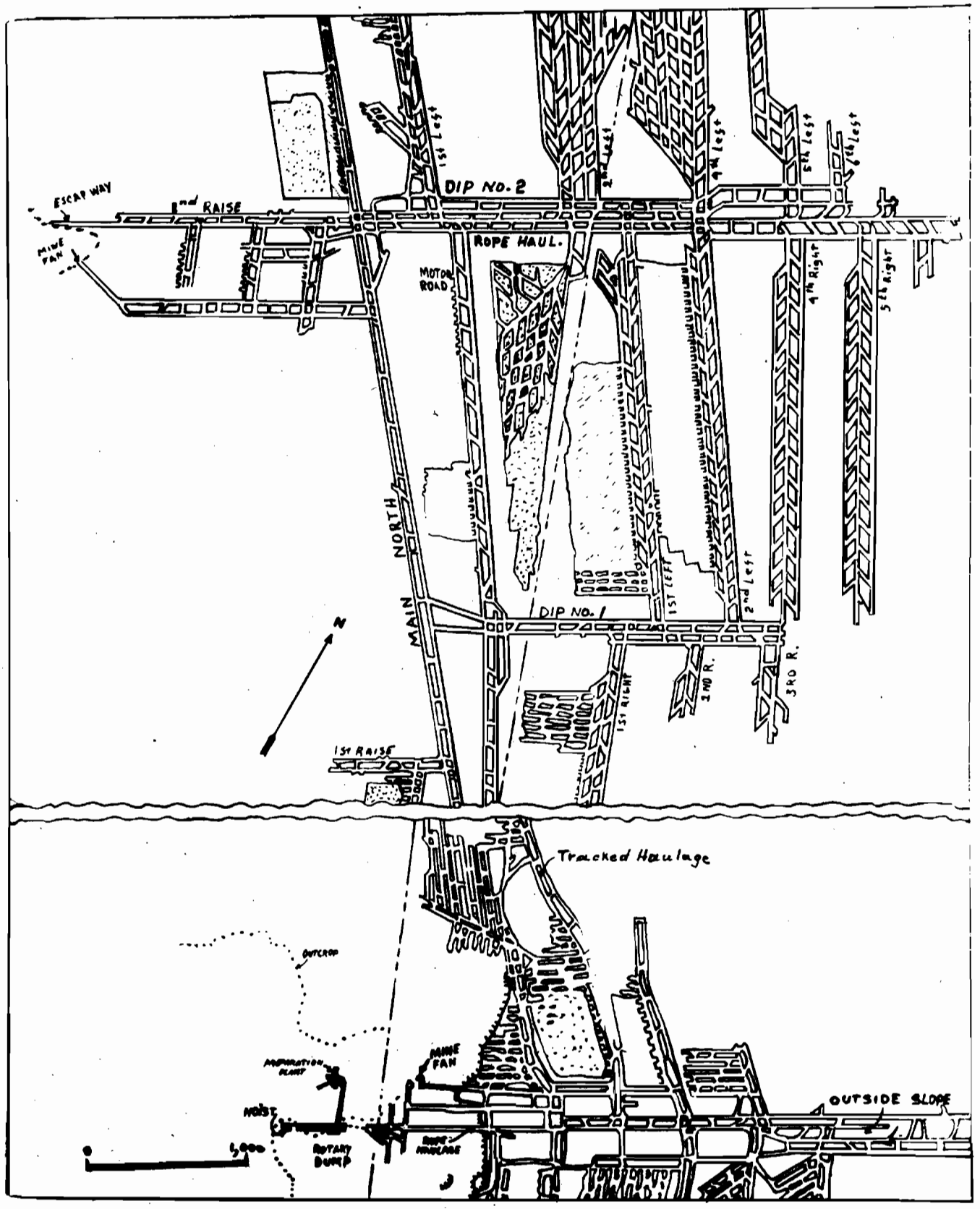


Fig. 1 —Mine Layout of Sunnyside No.1 Mine of Utah Fuel Company
(Mechanization, May 1949)

two, and others three entry systems. Slants (cross-cuts) are spaced on 150-ft. centers and are 18-ft. wide.

Mining Method.-- The room-and-pillar method of mining is well adapted; with the use of a variety of mechanical loading equipment, including track-and-crawler-mounted mobile loaders, duckbill shaking conveyors, and continuous miner. Each type of equipment is worked as a separate unit. Track-mounted units, including a universal type cutting machine with electric drill and track-mounted loader, are employed in driving entries. These track-mounted 360 Goodman loaders load one car at a time. The loaded car is delivered to the switch and an empty one placed next to the loader.

In trackless sections, crawler-mounted loading machines, short wall cutting machines and post mounted electric Dooley drills are used with the shuttle cars. The duckbill shaking conveyors are used chiefly in driving rooms and pulling pillars.

In development work, up to 4-ft. of top coal is being left for protection against roof falls. Top coal is not left while drawing the pillars.

The continuous miner is being experimented with in development work. This machine digs the coal from the face, and loads it onto a surge bin car at a high speed. However, it is not giving satisfactory results. It is further discussed in the second part of the thesis, and after certain problems

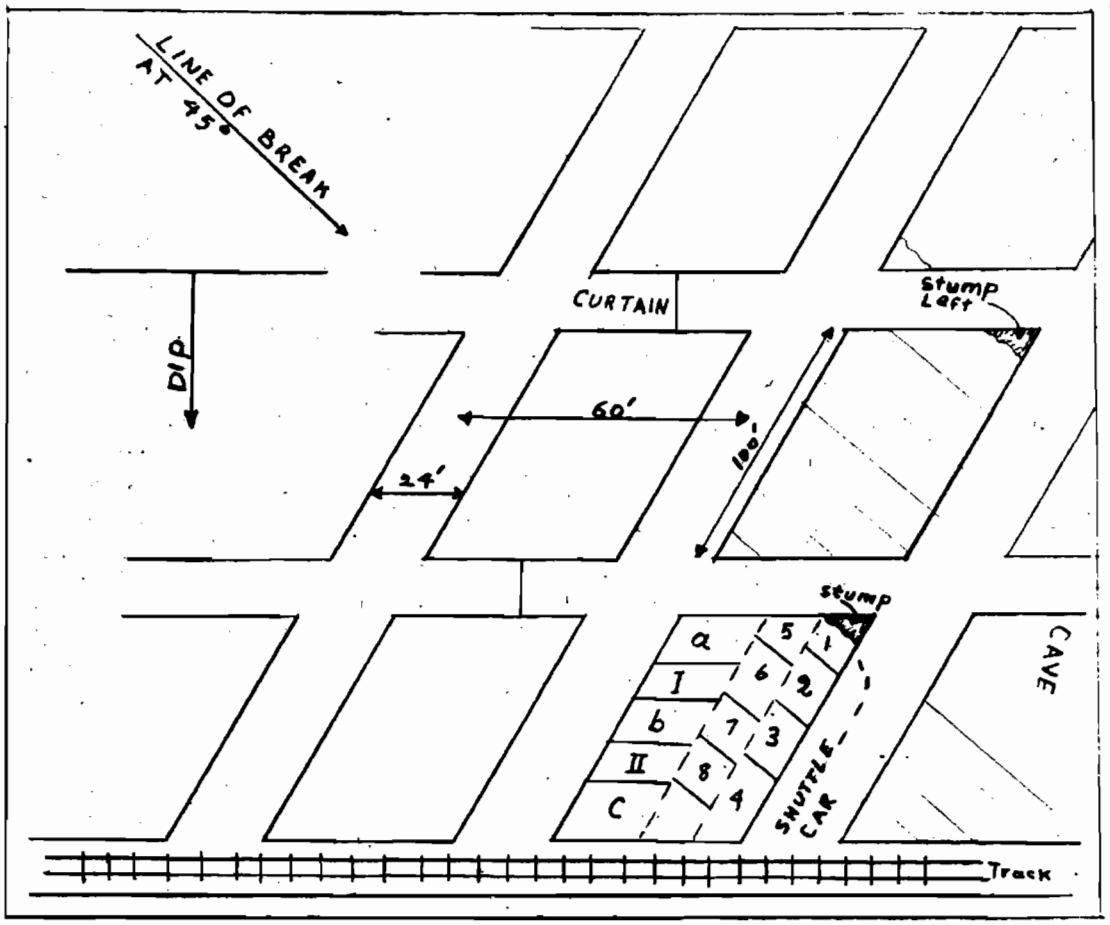


Fig. 2 – Pillar Extracting Method at Sunnyside Mine.

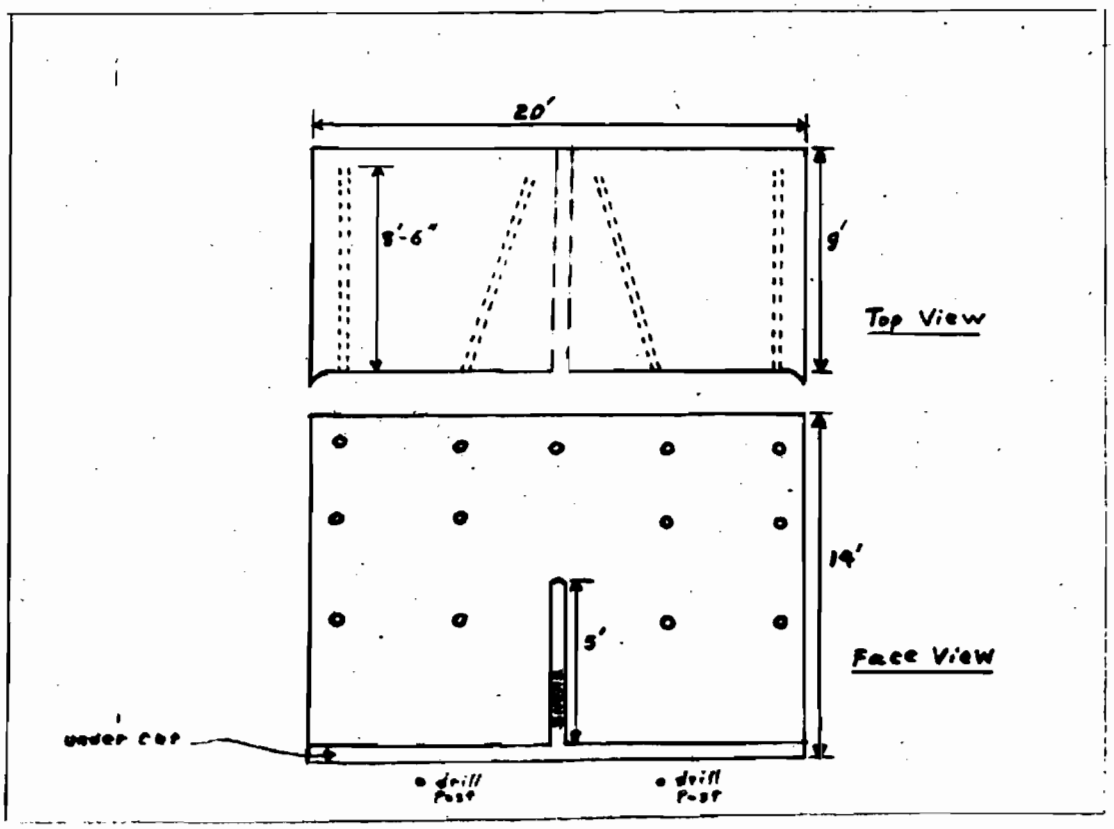


Fig. 3 – Face Preparation Diagram at Sunnyside Mine.

are solved, may prove satisfactory.

Room and Pillar Work.-- Upon completion of the development work, rooms are driven from the strike entries to the rise on 60-ft. centers, each being 24 to 30-ft. wide. Rooms are driven at 20 degrees to the strike entries in duckbill-shaker territories, and at 60 degrees in mobile loader sections.

Pillar extraction is conducted in the manner illustrated in Figure 2, which might be called a combination of the open-end and splitting methods. As shown in the figure, the cuts 1, 2, 3, 4, 5, 6, 7, and 8 are taken first, then the rest is mined by splitting in the following order: split I is driven; from split I the stump "a" is removed; split II is driven and from split II the stump "b" is removed; the stump "c" is removed from the entry. This method of extraction will give more recovery than the ordinary split method.

Face Preparation.-- The face, in driving entries, is prepared in the order shown in Figure 3. Track-mounted cutting-shearing machines undercut to a depth of 9-ft. and cut a center shear, also 9 ft. in depth, half-way up the face. Five top, 4 middle, and 4 bottom holes are drilled to a depth of 8.5-ft. using two set-ups of the drill post. That is, first the drill post is set on one side of the face and 7 holes are drilled; then it is set on the other side of the

face and the rest of the holes are drilled. Therefore, the rib holes are drilled straight, and the center holes angled in, producing a V-cut. The holes are shot in two series, the middle and the center ones first, then the top holes.

In pillar extraction and in rooms, undercutting and shearing are ignored, and the shooting is done on the solid with 14 holes. These holes are drilled in the same manner as described above. In sections where the roof is exceptionally tender, a top cut, a bottom cut and a shear cut are made.

Permissible sheathed explosives are used, each charge consisting of from 3 to 4 sticks. Charges are properly stemmed to the collar of the holes, and the holes are fired simultaneously. Drilling and shooting methods vary under different conditions.

Roof Support.-- Each district has its individual timbering standards, due to the varied conditions. Such conditions are faulted sections, and changes in thickness of the immediate roof with its inconsistent shale content. From 2 to 3 rows of timbers with cap pieces are used where needed. No timber is recovered.

Haulage.-- Transportation is accomplished by a combination of rope haulage and electric-locomotive track haulage. Loaded 5.7-ton mine cars are assembled in strike entries by 8-ton cable reel gathering locomotives. They are then hauled

to the partings of Dip Slope 1 or 2 and transferred to the rope haulage system. Coal from the room-and-pillar sections is discharged from conveyors or shuttle cars into mine cars and they are gathered similarly and pulled by locomotives to dip slopes partings where the trips are transferred to rope haulage. All transportation in slope entries, including the Outside Slope, 1st and 2nd Dips, is done with rope haulage.

Loaded cars raised in the slopes are transferred at the Main North parting for haulage to the Outside Slope by 15-ton trolley locomotives that haul trips of 12 loaded cars.

All haulage by rope or electric locomotives is coordinated in a smoothly running system, even though natural conditions present a difficult problem. Trolley phones are installed underground and on locomotives, providing a quick and effective communication system.

The track on strike entries is 40-lb. rail and on Main North, 60-lb. Wooden ties and a 40-in. gauge are used.

Ventilation.-- Two exhaust fans supply the fresh air to the mine at the rate of 240,000 CFM. These fans are mounted on the surface and are offset from return airways.

Since the mine is classed as gassy, no tubing blower fans are allowed underground, but brattice lines serve the same purpose. These brattice lines supply fresh air from the first inby cross-cut to within 15 or 20-ft. of the advance working face. The ventilation system is equipped with safety features, including safety signals and sirens. Stoppings and overcasts are air tight and put where necessary.

CHAPTER III

CASTLE GATE MINE, "D" SEAM

Castle Gate Mine, a property of Utah Fuel Company, is located at Castle Gate, Utah, about 2 miles east of U.S. Highway No. 6, and 5 miles northeast of Helper.

Use is made of track- and trackless-type mobile loaders and duckbill shaking conveyors in mining the coal. The mine, at present, is producing an average of 2,500 tons a day and employing from 260 to 265 men underground.

Seam Characteristics and Geology.-- In the Castle Gate Quadrangle, several coal seams are present, but only 4 or 5 of them are of economic importance. These seams named in order from the lowest up are: Castle Gate "A", Castle Gate "B", "Royal Blue", Castle Gate "C", and Castle Gate "D", or "Kenilworth." The Castle Gate "D" seam is being mined at the Castle Gate and Kenilworth mines.

All these coal seams occur in the Blackhawk coal-bearing formations of the Mesa Verde group, and are Upper Cretaceous in age. The Blackhawk formation, in this quadrangle, ranges from 900 to 1300-ft. in thickness, consisting of massive gray sandstone, sandy shale and coal beds. The coal beds are generally free from bone and shale partings, and range in thickness from a few inches up to 24-ft. The coal is of bituminous rank.

The coal bearing rocks are affected by faults at only

a few places. These faults have a small vertical displacement and small horizontal offset.

The "D" seam crops out about 175-ft. above the "A" seam; it ranges in thickness from 14 to 24-ft. and is under a cover varying from 1,500 to 2,000-ft. The roof consists of sandstone, limestone and shale, and varies from strong to weak as the shale content increases. The bottom is of shale and forms a fairly good floor.

The seam dips about 10-12 percent to the north. The coal is massive in structure, with little evidence of bedding. It is non-friable and strong. In this seam there is a rock parting which ranges from 0 to 6-ft. in thickness and makes the mining operation somewhat difficult. In development work, 6-ft. of top coal is left.

Mine Layout.-- The mine is entered through a rock tunnel which is 24-ft. wide and single tracked. This tunnel leads to the Main Haulage way, 1st Dip Slope, and 2nd Dip Slope. Fig. 4.

The First Dip Slope is driven down the dip of the seam at approximately right angles to the Main Haulage way as a two entry system. This First Dip Slope has a pitch of around 11 percent. About 2,200-ft. beyond the First Dip Slope is the Second Dip Slope, driven down at approximately an angle of 45 degrees to the Main Haulage way and in a northeasterly direction. The Second Dip Slope consists of 4 sets of entries and has a pitch of about 3 percent for a distance of 3,000-ft.,

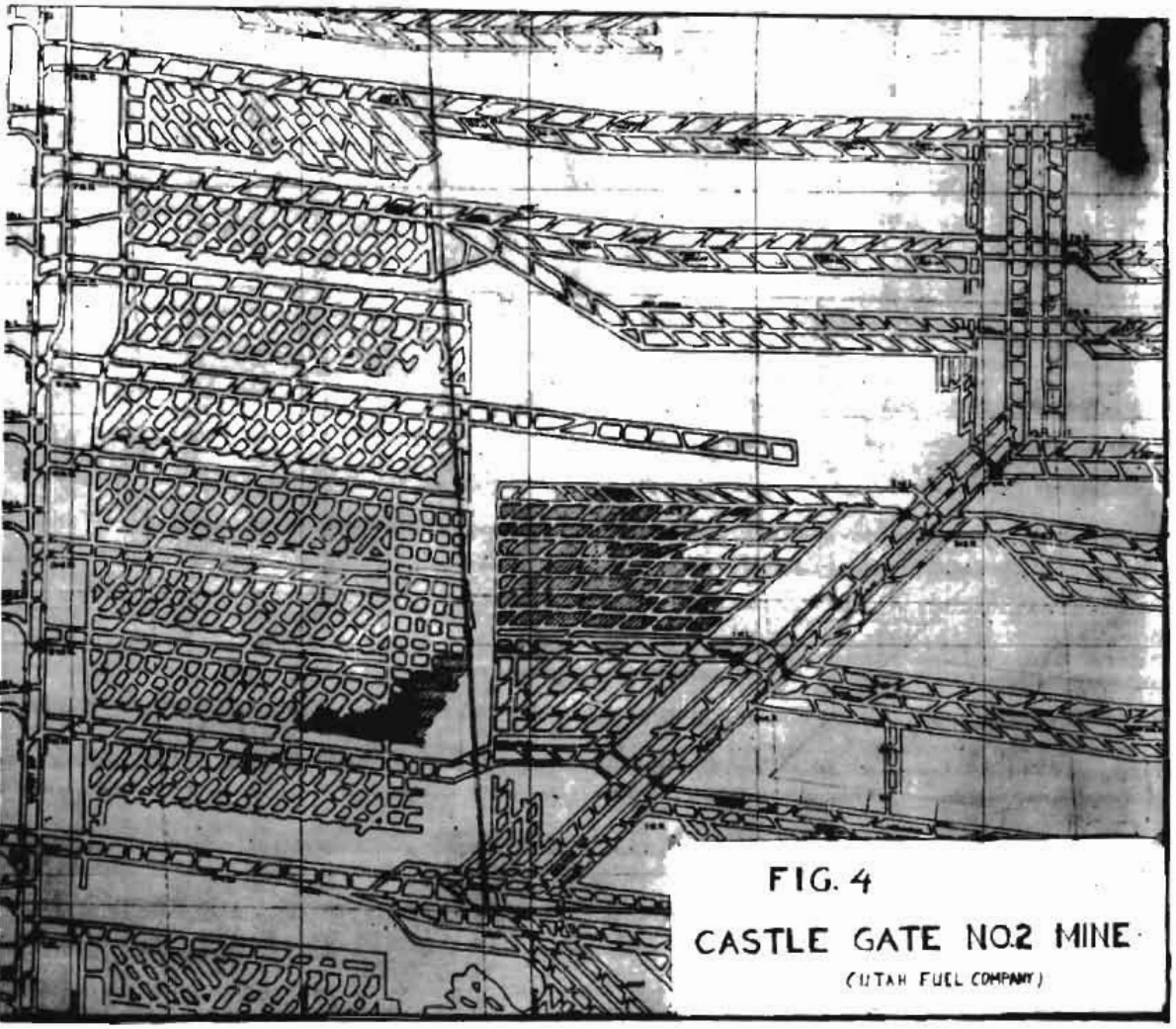


FIG. 4

CASTLE GATE NO.2 MINE

(UTAH FUEL COMPANY)

whereupon it runs parallel to the First Dip Slope and assumes the same pitch.

From Dip Slopes No. 1 and 2, the strike entries are driven off to the right and left approximately on the strike of the seam.

The Main Haulage road is a double entry system and is driven 24-ft. wide, on 70-ft. centers. All the slopes and entries are 18-ft. wide and are also on 70-ft. centers.

Mining Method.-- The retreat system of room-and-pillar method of mining has been adopted with the use of a variety of mechanical loading equipment, including track- and crawler-mounted mobile loaders and duckbill equipped shaking conveyors. Track-mounted units including 7 AU-cut and drill machines and Goodman type loaders are used in driving entries. These loaders in the entries load one car at a time, and wait until the next empty car is brought.

Crawler-mounted loaders (11 BU, cable reel type), 7B shortwall cut and drill machines, 10 RU rubber tired cut and drill machines and post mounted auger type drill machines are used in the trackless sections with shuttle cars, or with shaking conveyors.

In panels on the east side of Second Dip Slope, the shuttle cars are used in combination with shakers. A Joy loader fills the shuttle car in the room or crosscut, which then dumps the coal onto the shaker in the cross entry. Then the shaker transports the coal into the cars in the strike

entries.

Room and Pillar Work.-- Upon completion of development work, rooms are driven from strike entries to the rise on 50-80-ft. centers, each room being 18-20-ft. wide. The rooms are driven at an angle of 90 degrees to strike entries in duckbill shaking conveyor sections and at 45 to 60 degrees in mobile loader sections. The latter form sharp corners on two opposite ends of the pillar making pillar extraction quite difficult.

The common splitting method of pillar extraction is used. This is quite satisfactory where the roof stands well and conditions are favorable. However, a problem exists under bad roof conditions, especially in those places where the coal seam becomes thick, where the parting in the seam appears, and finally, where the shale roof is met.

Face Preparation.-- The face, in driving entries, is prepared in the same order as in the Sunnyside Mine (Fig. 3), except that no shearing is done. The undercut is 9-ft. deep, and 14 holes, each 8.5-ft. long, are placed as follows: 5 holes on the bottom row, 4 holes on the center row, and 5 holes on the top row. The center holes are angled up toward the center, forming a V-cut, and the holes on the rib are straight. Three to five sticks of permissible sheathed powder is placed in each hole, and stemmed to the collar of the holes.

The bottom row is fired first, then the middle, and last, the top row.

Sometimes a top cut is also used if roof conditions are bad. In room-and-pillar areas, drilling is done in the same manner, but as the face is widened, the number of holes is increased.

Haulage.-- Transportation in the mine is accomplished by a combination of track-and-rope haulage. Loaded 4-ton mine cars are assembled into trips in the strike entries by 7-ton battery type gathering locomotives. They are then hauled to the partings of the First or Second Dip Slopes, where they are transferred to the rope haulage system. These battery locomotives pull 5 loaded cars per trip. Coal from room-and-pillar sections is discharged from conveyors or shuttle cars into the mine cars which are gathered and hauled by locomotives to the Dip Slopes parting. All haulage in slope entries is done with rope haulage.

Loaded cars are raised up the slopes and transferred to the Main Haulage parting, and there hauled to the surface by 20-ton trolley locomotives, in 30-34 car trips.

The track on strike entries is laid with 40-lb. rail and on the Main Haulage road with 60-lb. rail. A 40-inch gauge is used.

The Castle Gate Mine has a nice haulage system. One especially noteworthy feature is the Main Haulage road which is clean and straight, resulting in quick, efficient

transportation.

Ventilation.-- The fresh air is supplied to the mine by two exhaust fans at the rate of 280,000 CFM. One fan is powered by a 600-hp and the other by a 225-hp motor. In the mine 3-inch of water gauge is obtained.

Airtight stoppings and overcasts are constructed in places where needed.

Since the mine is known to be gassy, no tubing blower fans are allowed in it; instead lines of brattices, which serve the same purpose, are used. These brattice lines lead the fresh air to within 20-ft. of the advance working faces from the first inby cross-cut. Although these brattice lines are more expensive than the blower fans, they work more efficiently.

CHAPTER IV

KENILWORTH MINE

The Kenilworth Mine is owned by the Independent Coal and Coke Company and is situated at Kenilworth, Utah, 120 miles southeast of Salt Lake City, and about 6 miles east of U.S. Highway No. 6, between Helper and Price.

The history of the mine dates back to 1904, but today it is one of the most modern mines in the United States. Kenilworth is, at present, producing about 4,000-4,500 tons of coal in a two-shift day and employing an average of 350 men underground.

Seam Characteristics and Geology.-- There are two mineable coal seams in this area. The upper one is being mined, and is called the Kenilworth seam, or the Castle Gate "D" seam. About 150-ft. below this is the Aberdeen seam, which is not being mined at present. These two seams are separated by layers of interbedded sandstone and shale, containing thin layers of coal.

The Kenilworth seam is relatively free from rock partings and great faults, but local rolls are often encountered across the seam, creating difficulty in maintaining a uniform haulage road. The thickness of the seam ranges from 9 to 16-ft. The coal is massive in structure and has little evidence of bedding. The rank of coal is bituminous and has a good heating value. The coal bed is free from rock partings, but in places troublesome rolls sometimes appear.

The roof is sandstone and forms a good top. The thickness of the cover over the seam ranges from 1,000 to 1,800-ft. The bottom is also of sandstone and gives a good road bed. The seam dips about 11 percent toward the north.

Mine Layout.-- The mine is entered through an 8,500-ft. long, 7-ft. high and 16-ft. wide rock tunnel, which is driven through sandstone and on a 1.5 percent grade in favor of loads. This tunnel connects with the Main East Entry (main haulage road) at a distance of 8,200-ft. from the portal of the mine. The Main East is driven as a set of triple entries for 3,800-ft. From there on it becomes a four entry system and follows an easterly direction, approaching the strike of the seam for a distance of 10,000-ft.

The Main East Entry divides the dip workings from the raise workings. The dip workings consist of slope entries driven downward from Main East and strike entries driven 90 degrees off the slopes at 250-300-ft. intervals. The raise entries are driven upward from Main East, and from these raises again the strike entries are established in the same way as the strike entries in dip workings.

The raises and the slopes are driven at right angles to the Main East at from 3,000 to 3,500-ft. intervals.

Because the coal seam dips toward the north, the sets of entries driven south of the Main East Entry and upward are called the raises, and the ones opposite to the raises which

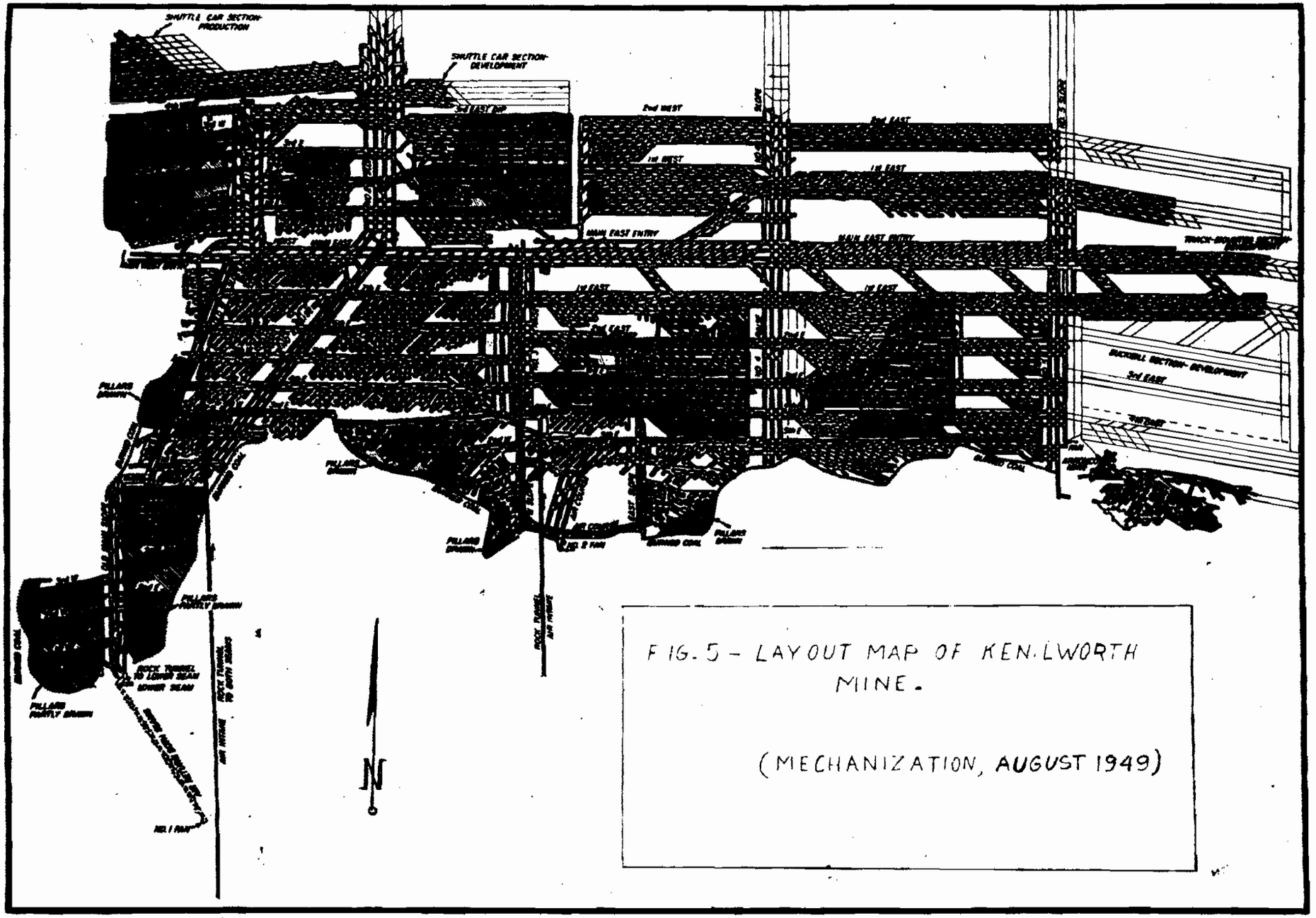


FIG. 5 – LAYOUT MAP OF KENILWORTH MINE.

(MECHANIZATION, AUGUST 1949)

are following down the dip are called the dip slopes. These raises and dips are numbered from west to north, the one farthest west being No. 1, and so on.

The headings in dip, raise and strike entries are driven on 75-ft. centers, each being 20-ft. wide. The cross-cuts (slants) and rooms are driven at 35-45 degrees to the entries on 125-150-ft. centers and are 18-ft. wide.

In development work, from 0 to a few ft. of top coal is left. That is, where the thickness of coal is less than 9-ft. and the roof behaves fairly good, no top coal is left. Otherwise, up to 5-ft. of top coal is left.

Mining Method.-- The retreat system of the room-and-pillar method of mining is used in conjunction with a variety of mechanical loading equipment, including track- and crawler-mounted mobile loaders and duckbill equipped shaking conveyors. In driving entries either track-mounted units, including a universal cutting machine with electric drill and track-mounted loader, or duckbill shakers with shortwall cutting machines and post-mounted drills are used. In trackless sections universal rubber tired cutter and crawler-mounted loaders are used. These crawler-mounted loaders discharge into shuttle cars.

Room-and-Pillar Work.-- In room-and-pillar work, pillar blocks, having dimensions not greater than 1,200-ft. by 2,500-ft. are developed by driving the above described strike and

dip entries. At a point 500-ft. back from the predetermined barrier on the strike entry, a panel haulway is driven down the slope at 45 degrees to the strike entry (See Fig. 6; track shown with dotted line). To insure a maximum haulage distance of 500-ft. from the loading station to the discharge end, advance loading stations are installed on either side of the haulage way, and track is laid on the panel line. A hoist is placed on the cross-cut between the second and third upper strike entries. After this has been established, Joy loaders and shuttle cars are employed on both sides of the panel line. While the pillar is being pulled on the retreat side, the development work is being advanced on the other side; thus the shuttle car development and the pillar extraction should be simultaneous and kept in sequence at all times. Both sides of each panel should finish together. When pillars are drawn back to the panel haulage a new set-up is made in the next haulage panel and the mining process is repeated.

While the present system uses rope haulage on the panel line; a belt transportation system is being considered by the management for the future.

The theory of this method of development on retreat work is to produce pillar blocks directly ahead of pillar extraction, thus eliminating the possibility of long standing pillars taking weight and bouncing when they are finally disturbed. A retreating pillar line (line of break) is developed parallel to the panel haulage, thereby keeping all developed blocks the same distance from the cave line.

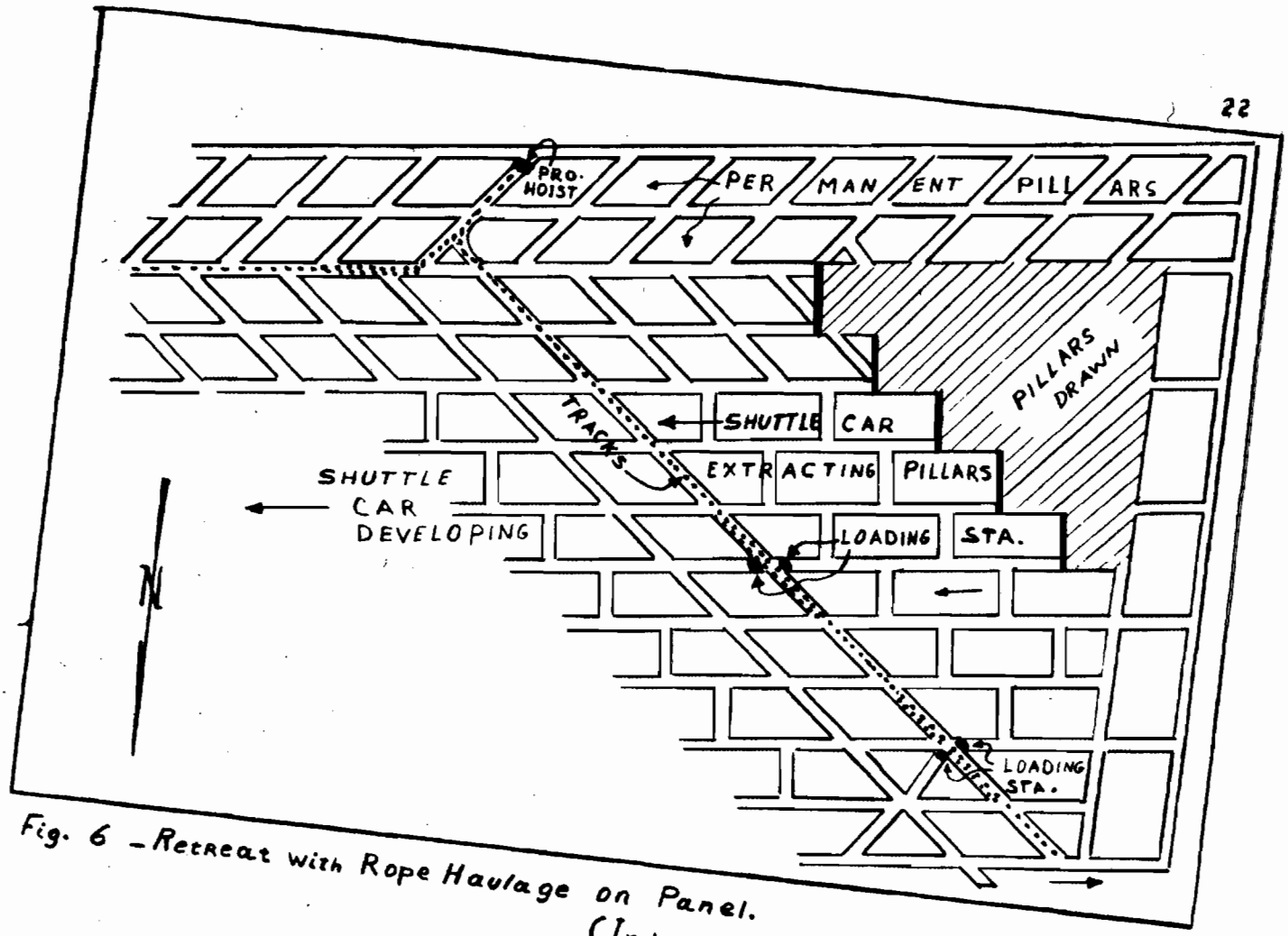


Fig. 6 - Retreat with Rope Haulage on Panel.
(Independent Coal & Coke Company)

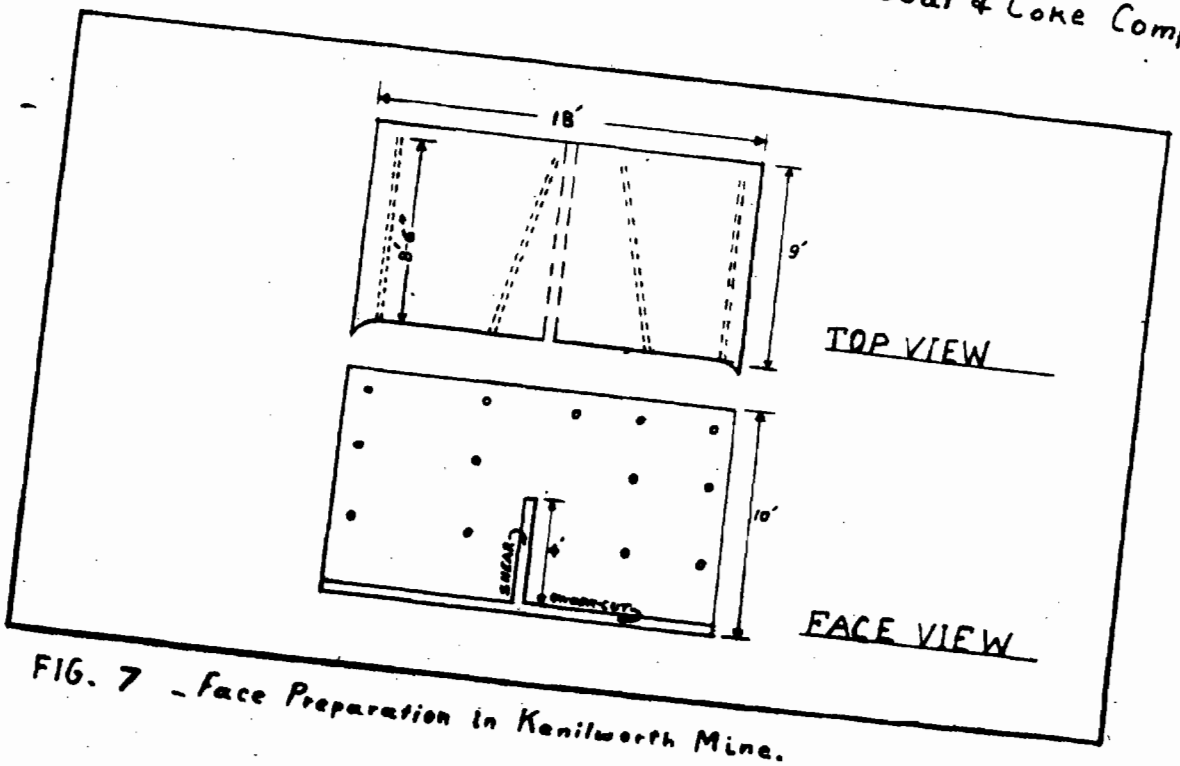


FIG. 7 - Face Preparation in Kenilworth Mine.

In these pillar blocks, the rooms are driven from the panel lines parallel to the strike entries on 75-ft. centers, each being from 18 to 20-ft. wide. The cross-cuts are driven on 125-150-ft. centers and are 20-ft. wide.

The pillars are drawn by the splitting method. In the Kenilworth Mine, the pillars left in room work are diamond shaped. Squared ones were tried in the past, but they resulted in too high a pressure when mined and tended to slough badly. Now all the pillars left are diamond shaped and have a tendency to release the pressure gradually, resulting in less sloughing while drawing them.

Face Preparations.-- The face preparation is done in the order shown in Fig. 7. The cutting is established with track-mounted and rubber-tired universal cutting-shearing machines. In driving entries and rooms where the face is 10-ft. high and 18-20-ft. wide, an undercut 9-ft. in depth and a shear cut with the same depth and 4 to 5-ft. from the bottom is made. This shearing may be ignored or a full shear may be made, depending upon the conditions present. In pulling pillars, for instance, the coal is usually shot on the solid (without cutting).

When using under- and shear-cutting, 14 holes are drilled, each 8.5-ft. in depth, as shown in Fig. 7. The center holes are angled toward the center, forming V-cuts; the holes on the rib are straight. As the face is widened or the cuts ignored, the number of holes drilled is increased accordingly.

Each hole is loaded with 3-4 sticks of permissible, sheathed powder, and stemmed properly to the collar of the hole. The rows are detonated successively from the bottom up.

Haulage.-- The transportation at Kenilworth Mine is accomplished by a combination of track-, rope and trackless-haulage, with shuttle cars. Loaded 4- or 6-ton cars are assembled in strike entries into trips by battery or cable reel type gathering locomotives and hauled to the partings of raises or dip slopes. At the partings these cars are lowered or raised depending upon their location with reference to Main East Entry (main haul way).

Coal in shaker territory is loaded into the cars directly by shakers, and in mobile loader sections shuttle cars empty the coal into an elevating conveyor at the loading station.

The haulage on the Main East Entries is done by 15-ton trolley locomotives. Main haulage distances to the tipple run up to 5 miles. Since the rock tunnel was driven on 1.5 percent grade in favor of loads, the haulage in this section uses gravity instead of power, i.e., the trip is taken outside by the force of gravity and the problem of braking has been solved very cleverly by the use of soft-iron skid shoes placed under the left front wheels of the first four cars.

The main haulage line is double tracked, one for empty trips and the other for loaded trips. The track for the loaded trips is 75 lbs., for the empty, 60 lbs., and at the

faces, 50 lb. rail. A 42-inch gauge is used and the rails are welded.

The haulage system at Kenilworth Mine, as a whole, has been very well planned and a safe smooth system has resulted.

Ventilation.-- Two centrifugal exhaust fans supply the fresh air to the mine at a rate of 300,000 CFM. Since the mine is growing and the distances involved are increasing, a new fan installation is being completed. There are five intakes and some of them work with natural ventilation; therefore, a low water gauge in the mine is possible.

Airtight permanent stoppings and overcasts are constructed of concrete, or cinder blocks. Since the mine is classed as gassy, no tubing blower fans are allowed to supply the fresh air to the advance working faces, but the rubberized type brattice cloth is being used with satisfaction in leading air to within 20-ft. of the working face.

CHAPTER V

GENEVA COAL MINE

The Geneva Coal Mine, a property of Geneva Steel Company, is a subsidiary of the United States Steel Corporation. It is situated in Horse Canyon, on the eastern rim of Castle Valley, which is about 35 miles southeast of Price, Utah, and approximately 160 miles southeast of Salt Lake City, Utah.

The initial development of Geneva Coal Mine was begun in 1942, and the Geneva Steel Company began operating in 1943 for the Defense Plant Corporation. On June 16, 1946, Geneva Mine was purchased from the War Assets Administration by the United States Steel Corporation.

This mine has a rated output of 8,500 tons per day, but this quantity of production has as yet not been required. At present, the mine is employing an average of 780 men and producing 5,000-5,500 tons per double-shift day. All coal is shipped to the Geneva Steel Plant.

Seam Characteristics and Geology.-- The coal seam being mined at Horse Canyon is the Lower Sunnyside Seam. The Upper Sunnyside Seam, which was described previously, also exists in this district, but is not mined. The coal in both seams is sub-bituminous in rank, and is in the Blackhawk formation of the Mesa Verde group and of Upper Cretaceous age. The depth of cover ranges from 300 to 2,900-ft. The roof is of sandstone, shale, and in some places, limestone. The bottom of the seam is a massive sandstone.

The Lower Sunnyside Seam, which is being mined, is from 12 to 14-ft. thick. The seam dips about 12.5 percent to the east. The coal seam is relatively free from rock partings, except at the bottom level and in the extreme southeast section of the mine. Since there is no preparation plant on the surface, and sorting underground is impractical, this rock layer in the coal in places gets thick enough to become troublesome. The coal has no definite cleats or cleavage planes, but has slips which are at 45 degrees to the strike of the seam. The coal has a relatively low (0.8 to 1 percent) sulphur and ash content and has a good coking property.

There are numerous faults in this area, both normal and reverse. These faults usually strike east-west. The displacements of the faults are usually less than 15-ft. However, there is one fault estimated to have a displacement of 55-ft.

Mine Layout.-- As mentioned above, the coal seam is highly pitching and faulted. Thus, the layout of the mine is mainly influenced by these two factors.

The mine is entered through a rock tunnel originating at the surface, on a dip of 3 percent. The rock tunnel connects with the First Level (first set of main strike entries) at a distance of 1300-ft. from the portal. Adjacent and parallel to this tunnel are a hoist way and a fan entry, driven on level grade. All these entries connect with the First Level. The First Level, which consists of a set of four

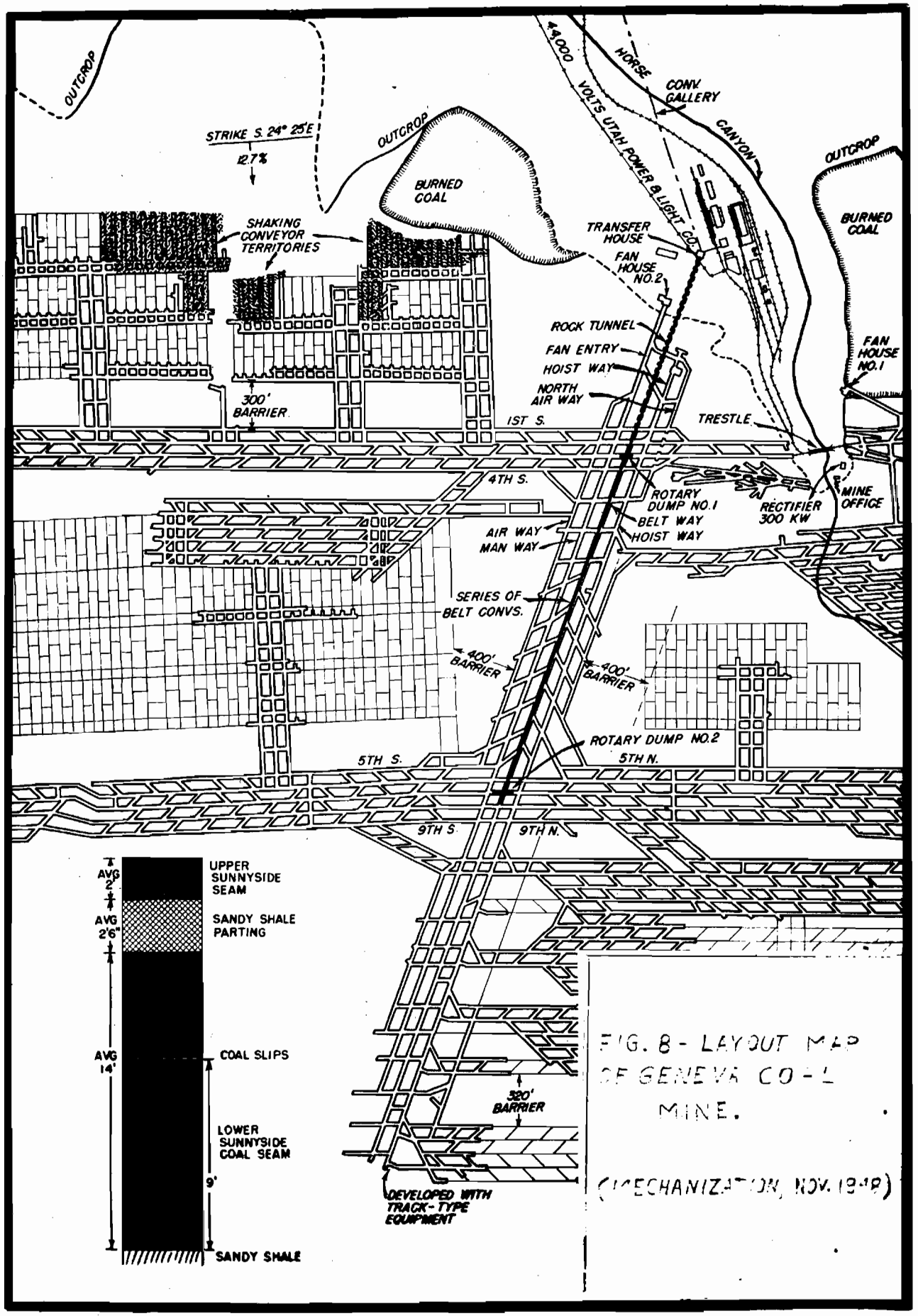


FIG. 8 - LAYOUT MAP OF GENEVA COAL MINE.

(MECHANIZATION, NOV. 1948)

entries, runs south to north on the strike of the seam. From the First Level entries the raises and dip slopes are driven off at approximately right angles.

The First Level is connected with the Second and Third Levels by four sets of dip slope entries. These slope entries are on a 12 percent dip and follow the same direction as the rock tunnel. From the Second and the Third Levels, the raises and dips are driven off in the same manner as on the First Level. These raises and dips are connected with cross entries, which are nearly at right angles and are on the strike of the seam.

All the entries and slopes are 18-ft. wide and on 80-ft. centers. The cross-entries are also 18-ft. wide, but on 60-ft. centers. The dip slope between the First and Second Levels, and the Second and Third levels is 2,400-ft. long.

Mining Method.-- The retreat system of room-and-pillar method of mining is employed, together with the use of a variety of mechanical loading equipment. These include track- and crawler-mounted loaders and duckbill equipped shaking conveyors.

All main strike and dip entries are driven with track-mounted mobile loaders. This development work usually consists of four parallel, 9 x 18-ft. entries, which are driven on 80-ft. centers. Crosscuts are driven off the main strike and dip entries at every 100-ft. to the right and also to the left, at a 45 degree angle. Crosscuts from the outside entries of each set are turned at 200-ft. intervals and at 45 degree angles,

each being 16-ft. wide and 9-ft. high.

Shaking conveyors are used chiefly in driving raise and cross entries, rooms, and in pulling pillars. The raise entries are driven in 2 and 3 sets, at 600-ft. intervals. The cross entries are perpendicular to the raise entries and at 320-ft. intervals. The rooms are then driven up the pitch on 60-ft. centers and widened to 25-ft. after 2 or 3 cuts. Crawler-mounted mobile loaders are used mainly in driving through faults and also in room-and-pillar work.

In development work the seam is mined to a height of 9-ft., leaving 5-ft. of top coal. This top coal forms a good roof and is recovered during retreat work with the pillar extractions.

Room-and-Pillar Work.-- Upon completion of the development work, rooms are driven up the pitch on 60-ft. centers and widened to 25-ft., after 2 or 3 cuts. Pairs of rooms are driven from each cross entry in such a way that while one pillar is being extracted from a room, the advance work is carried on in the adjacent room. This provides a roof breakline of 45 degrees to the rooms. While advancing a room, two cuts into the solid are made on 65-ft. centers. Both cuts are taken and 4 props are set in each. The center crosscut of each room is connected through the pillar side for ventilation; the other two are connected during the retreat of the room and pillar.

In pillar extraction, the split method is used with duckbill equipped shaking conveyors, as shown in Figure 9.

METHOD

A- DRIVE MAIN CROSS-ENTRIES ON 60' CENTERS, AT WIDE A ABOUT 5' HIGH, UP TO 6.5' IN COAL HEAD 5' IN HEIGHT FOLLOWING ROOF RISE.

1- DRIVE FIRST THREE CROSS-CUT THROUGH. THE TWO SOLID CUTS BETWEEN ARE LEFT WITH A MINIMUM CUTTING OF COAL AS A STOPPING.

2- OFFSET MAIN CROSS-ENTRY BELT 5' SO SIDE OF FRAME IS ON 6' OF ENTRY.

B- DRIVE ALL CROSS-CUTS 6 ROOM HEADS 60' WIDE AND ABOUT 6' HIGH, ROOMS DRIVEN ON 60' CENTERS & SEPARATED TO 30', AND ABOUT 6' HIGH.

C- ON ADVANCING ROOMS HAVE 2 CUTS INTO SOLID FOR ON 60' CENTERS (CUTS CARE TO BE LEFT OUT 6 A CROSS CUT NO CROSS) AS 3 LOCATIONS MEASURED FROM PREVIOUS BREAKER AT FACE. THESE POINTS ARE 1ST. - 60', 2ND. - 90', 3RD. - 150'.

1- CUTOUT CROSS-CUT IN PILLAR SIDE, AT GROUND LOCATION, ON ADVANCE.

D- PUSTEANTS TIMBERING OF ROOMS TO BE FOLLOWED PLACED PROPS ON 6' CENTERS, AS SHOWN. SET 3 RE-SET ONE ON MAIN SAFETY PROPS DURING ALL MINING OPERATIONS AT FACE. THESE PROPS, OR SOME IF NEEDED, SHALL BE SET AHEAD OF DRIVEL.

E- AFTER ADVANCE HAS BEEN COMPLETED AND BEFORE PILLAR SPLIT IS PILLAR HAS BEEN DRIVEN, THE BREAKER ROW & EXTRACT TOP COAL AT END OF ROOM

1- BREAKER ROW TO BE 15' IN-BY POINT OF STUMP THAT IS TO BE LEFT ON PILLAR EXTRACTION.

2- BREAKER ROW SHALL CONSIST OF TWO CROSS-CUTS POSTS TO BE USED NEXT TO GOAF AT END OF ROOM OF HEADING.

3- MINING SUPERVISOR WILL DETERMINE THE LOCATION OF BREAKER ROWS IN THE EXTRACTION OF TOP COAL.

F- WHEN PILLAR SPLIT IS STARTED, MAKE ONLY ONE CUT ACROSS PILLAR. MINING SUPERVISOR SET LOCATION FOR POINT OF STUMP, AS SHOWN.

G- RECOVER AS MUCH TOP COAL AS IS CONSISTANT WITH SAFETY & BLAST OUT STUMPS CONSIDERING CLEAR CAVE TO BREAKER ROW.

H- CARRY SHOVEL & SLIDE PAN NEXT TO DUCKBILL.

I - KEEP CUTTING MACHINE ON SOLID PILLAR SIDE AT A SAFE DISTANCE FROM THE FACE WHEN NOT IN USE.

J- ADEQUATE VENTILATION TO BE MAINTAINED AT THE FACE WITH BRATTICE LEADS.

LEGEND

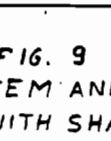
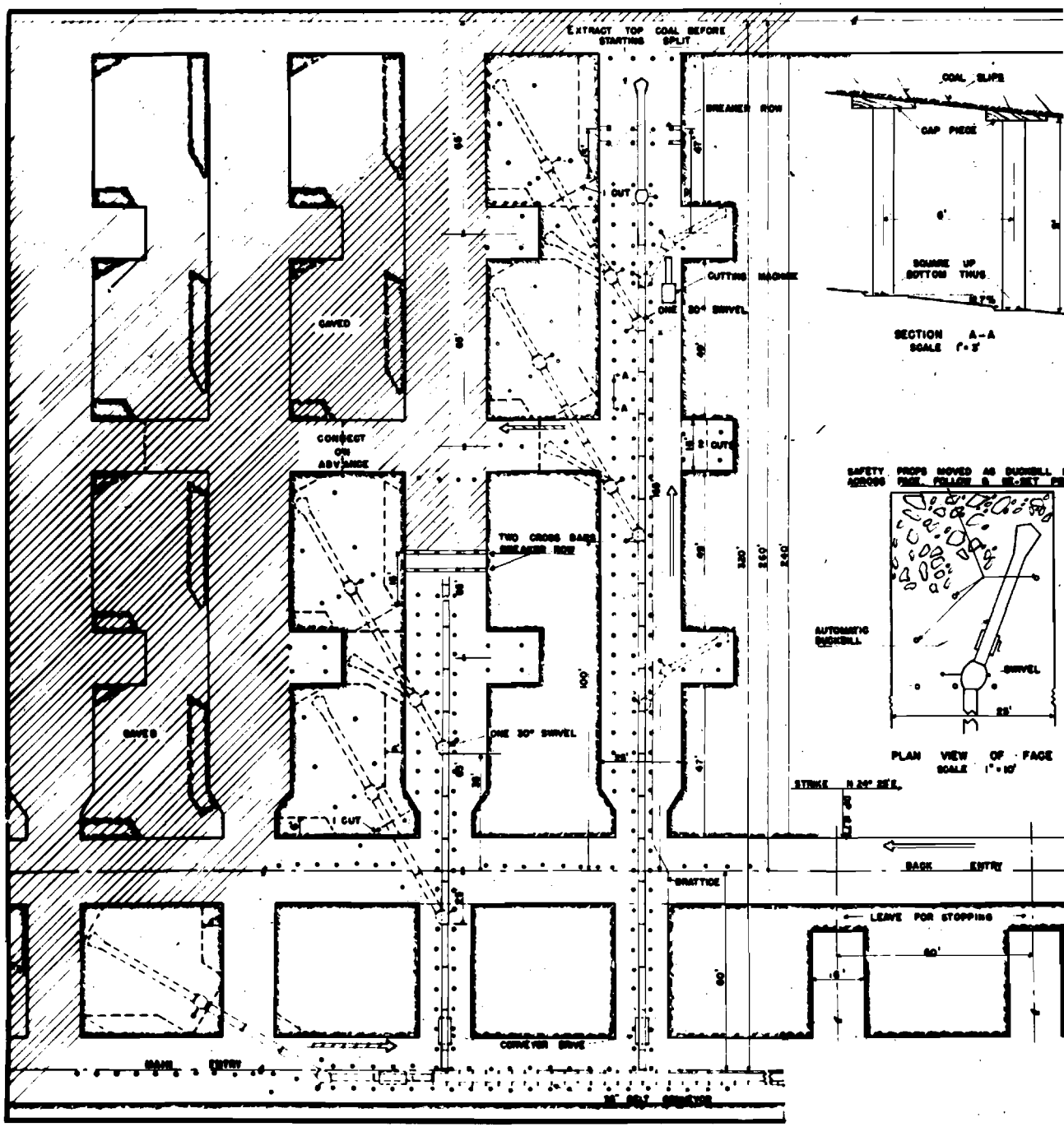


FIG. 9 RAISE MINING SYSTEM AND PILLAR EXTRACTION WITH SHAKING CONVEYOR.

(GENEVA STEEL COMPANY)


EXTRACT TOP COAL BEFORE STARTING SPLIT
BREAKER ROW
CUT
CUTTING MACHINE
ONE 30° SWIVEL
CONNECT ON ADVANCE
TWO CROSS BARS BREAKER ROW
ONE 30° SWIVEL
CUT
BRATTICE
LEAVE FOR STOPPING
CONNECTOR DRIVE
MAIN ENTRY
BACK ENTRY
STRIKE N 24° 25° E.
COAL SLIPS
CAP PIECE
SQUARE UP BOTTOM THUS
SECTION A-A
SCALE 1" = 5'
SAFETY PROPS MOVED AS BUCKBILL
AUTOMATIC BUCKBILL
SWIVEL
PLAN VIEW OF FACE
SCALE 1" = 10'

The conveyor operation is also fully explained on one side of the same figure.

Face Preparation.-- The face preparation in this mine is done in the same order as in the Sunnyside Mine; thus the same Figure (3) is applicable. In all development work, the face is under-cut to a depth of 9-ft. and a center shear is usually cut half-way up the face. This is done both with track-mounted and trackless equipment. The room faces where shakers are used are cut with shortwall cutting machines and drilled with post-mounted electric drills. Drill holes are 8.5-ft., i.e., 6-in. shorter than the cuts, to avoid any possibility of shooting on the solid.

Permissible sheathed powder is used, each charge consisting of from 3 to 4 sticks. Each hole is properly stemmed to the collar.

Haulage.-- Transportation at Geneva Coal Mine is accomplished by a combination of belt and chain conveyors and rope and track haulage. The transportation system in use at this mine is an outstanding feature of the operation. In the entries coal is loaded with track-mounted mobile loaders into 8-ton mine cars. Loaded cars are assembled into trips by 10-ton electric gathering locomotives. These trips are taken from an inby assembly station to either of two rotary dump stations at the dip slope (one on the First Level, the other on the Second Level) by 15-ton electric locomotives. All coal mined below the Second Level is hoisted to this Level

by a rope hoist, because the belt does not extend below the Second Level.

Coal in room and pillar work is loaded by duckbill equipped shaking conveyor and discharged onto either a chain conveyor or a 36-inch belt conveyor which is installed in the main cross entry. In the territories where shuttle cars are used, the coal is loaded by crawler-mounted mobile loaders into 6-ton shuttle cars and transported to an elevating conveyor for discharge onto a 36-inch belt conveyor. The shuttle cars have an elevating discharge head and can therefore empty the coal directly on the belt if necessary. These belt conveyors in the cross entries deliver the coal to another 36-inch belt that is installed in the main raise entry. This conveyor discharges the coal into an elevating conveyor car loader. Each car is spotted under the discharge point by a car-spotting hoist. The loaded cars are then taken to the rotary dumps by a 15-ton locomotive.

From the dump station, a 54-inch belt conveyor transports the coal up the dip, in four lifts, a distance of 2,200-ft., and discharges it into the hopper of the First Level rotary dump. The First belt (lift) is 250-ft. long and on a 15-degree slope, the Second is 643-ft. long and on a 12 percent slope. The remaining two are identical to the second one.

The belt from the First Level to the surface (through the rock tunnel) is 1,300-ft. long, 54-in. wide and on a 3 percent slope. It receives coal from both rotary dumps, and delivers this to the transfer house on the surface. This

coal is discharged onto a 48-inch belt conveyor, 3,300-ft. long, which then takes the coal to the tipple through a conveyor gallery.

The man trips and the supplies are transported through the main Third South portal to a rope terminal at the main slope. There they are lowered to any parting along the hoistway.

Ventilation.-- Two Jeffrey Aerodyne exhaust fans supply the fresh air to the mine at a rate of 350,000 CFM. The north fan exhausts the openings north of the main hoist slopes at a rate of 150,000 CFM against a 2.7 inches water gauge. The south fan exhausts the districts south of the main slopes at a rate of 200,000 CFM against a water gauge of 1.6 inches.

The mine is classed as non-gassy, so that auxiliary blower fans can be used to supply fresh air to within 80-ft. of the advance working faces. These tubing-blower fans are used only in track-mounted mobile loader districts. In shaker territories brattice lines are preferred.

All mined out areas are sealed off with fire seals. Overcasts are constructed of cinder blocks and reinforced concrete. Temporary stoppings are of metal lathe and plaster, supported by 1-in. board. The permanent stoppings are of cinder blocks and plastered with cement.

CHAPTER VI

D. O. CLARK MINE

The D. O. Clark Mine, a property of the Union Pacific Coal Company, is located at Superior, Wyoming, about 15 miles north of U.S. Highway No. 30.

At present most of the tonnage comes from shaking conveyors. The mine is producing 4,000 tons of coal in a two-shift day, from 4 seams, and employs an average of 500 men underground.

Seam Characteristics and Geology.-- There are four mineable seams in this area. Under 600-ft. of sandstone and shale cover, the coal seams are separated by inter-bedded layers of black shale and sandstone in the order shown in Figure 12. They occur in the northeastern rim of the Baxter Basin.

The coal is of bituminous rank and Cretaceous age. The seams dip 4 degrees to the west and range in thickness from 4 to 14-ft. There are no faults of great importance. The roof is of black shale and sandstone, and varies in strength as the composition changes; the higher the shale content, the weaker the roof. The coal itself is quite friable.

In development work from 1.5 to 4-ft. of top coal is left. At present, the mine is non-gassy. Some impurities like sulphur and pyrites are present in the seam.

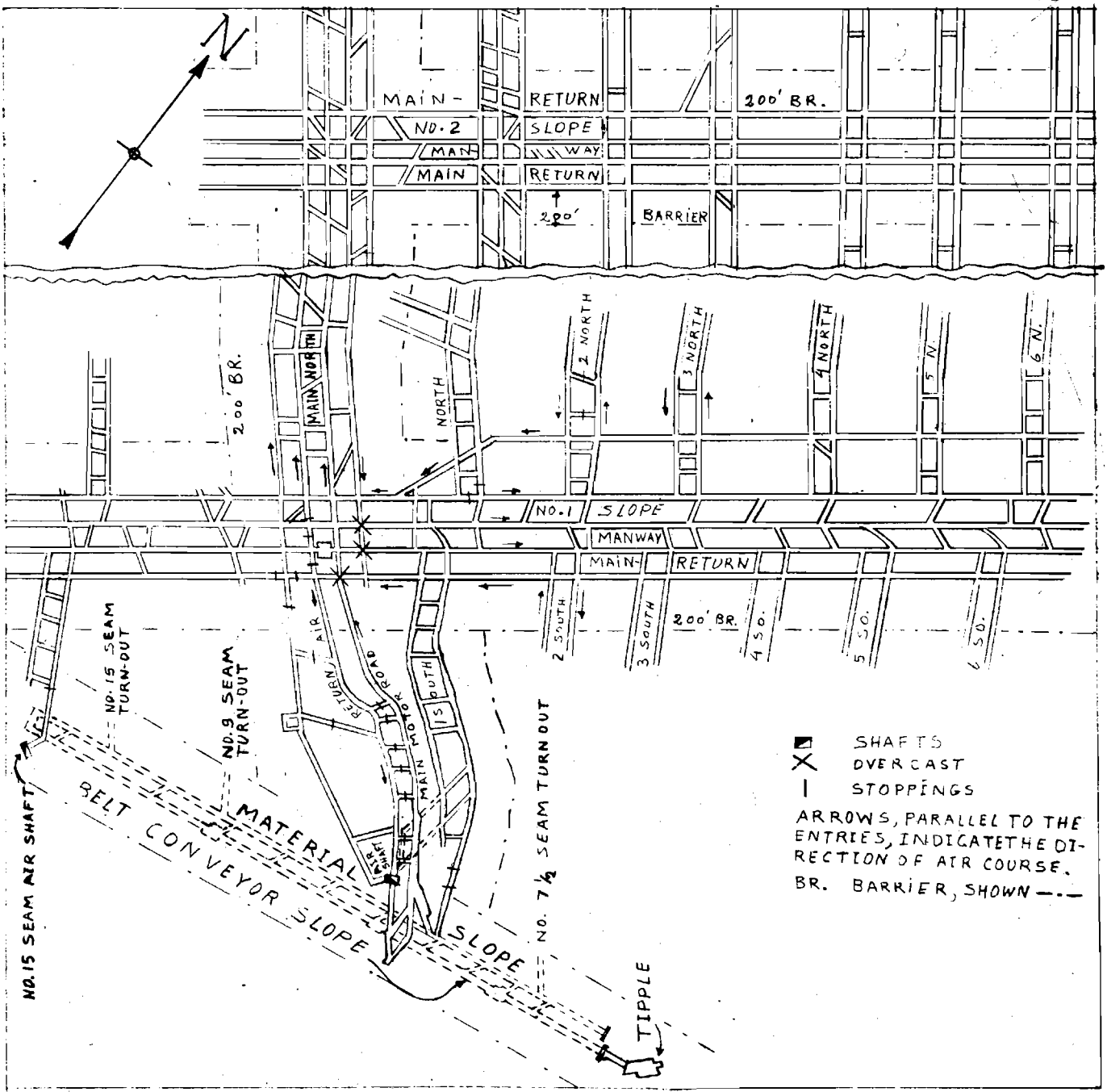


FIG. 10 - THE UNION PACIFIC COAL CO. - D. O. CLARK MINE NO. 7 SEAM. MINE LAYOUT.

(Courtesy of Union Pacific Coal Company)

Mine Layout.-- The mine is entered through two slopes. In one a belt conveyor is installed for hauling the coal, in the other rope haulage is used for handling material and transporting the men. These slopes are driven on 50-ft. centers and 18 percent dip. A 48-in. wide and 2,500-ft. long belt serves four seams at the same time. There is a turnout station for each seam where the slope cuts them. At every turnout there is a rotary dump for transferring the coal from the mine cars to the belt conveyor. The belt then takes the coal to the tipple which is located on the surface.

From the turnout station on No. 7 seam, two entries (one a motor road, the other for air return) are driven nearly on the strike of the seam, in favor of the load. These entries lead to the Main North, No. 1 Dip Slope, and No. 2 Dip Slope. The No. 1 Dip Slope is driven down the dip of the seam at approximately right angles to the Main North entries. About 4,000-ft. beyond the No. 1 Dip Slope is the No. 2 Dip Slope driven parallel to it. These slopes and the Main North consist of four sets of entries which are driven on 70-ft. centers. The strike entries are driven at approximately right angles to the dip slopes and at 300-ft. intervals. These strike entries are a two entry system.

Mining Method.-- The room-and-pillar method of mining has been adopted with the use of duckbill shaking conveyors and mobile loaders. These include the shortwall cutting machines and the Chicago "Little Giant" drills.

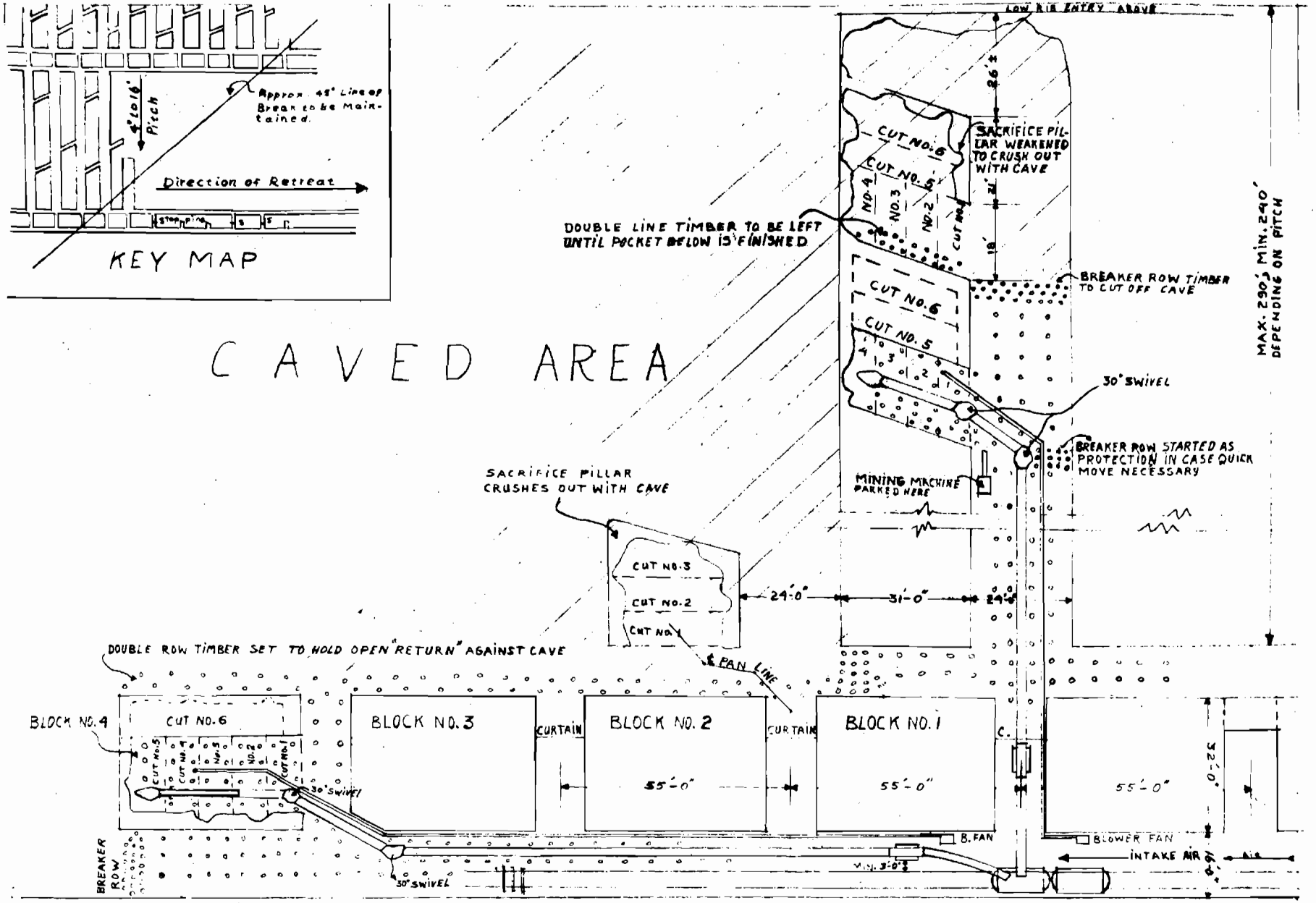


FIG. 11 _ SHOWING METHOD OF EXTRACTING ROOM AND ENTRY PILLARS WITH DUCKBILL-SHAKING CONVEYOR. U. P. COAL CO. MINES AT ROCK SPRINGS, WYOMING

(courtesy of Union Pacific Coal Company)

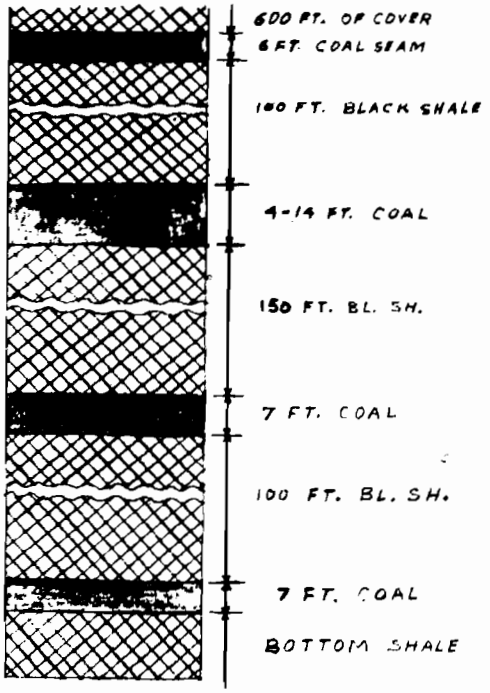


FIG. 12 SHOWS THE CROSS SECTION OF SEAMS OF D. O. CLARK MINE.

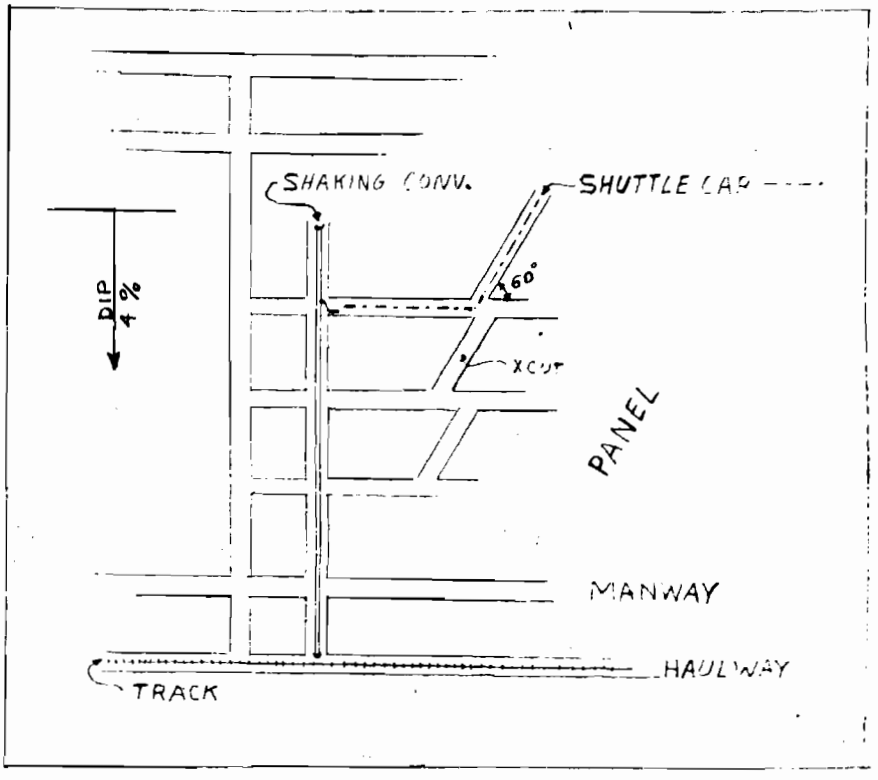


FIG. 13_ SHAKER & SHUTTLE CAR IN PANEL WORK.

The mine was developed with the shaking conveyors only, but recently, the company has put two shuttle cars (cable reel type) in combination with 14 BU Joy loaders for panel work. The working system of shuttle cars in panels is illustrated in Figure 13; the Joy loads the shuttle car at the working face which then dumps the coal onto the shaker in the cross entry. Then the shaker discharges the coal into the mine cars in the haulageway.

The rooms are driven at angle of 90 degrees to the strike entries on 55-ft. centers. The maximum depth of the rooms is 300-ft. and width is 24-ft.

Pillar Extraction.-- The pocket-and-stump system of mining pillars is employed. Figure 11 illustrates the pillar extractions with duckbill shakers in rooms and entries. As shown in the key map of the same figure, a break line that makes a 45 degree angle with the direction of retreat is maintained. This whole system has been standardized by the Union Pacific Coal Company and is used by all mines that are operated by them. The distinguishing feature in this method is that while one pillar is being mined on retreat, an adjacent room is being advanced.

In extracting the blocks of pillars, 18 to 20-ft. wide 6 to 7-ft. long cuts are taken in the order shown in Fig. 11. A sacrifice pillar is left on the caved area side. It is weakened enough to crush out after timbers are pulled. Before taking the timbers from the mined block, the breaker row timbers are installed near unmined block to limit the cave

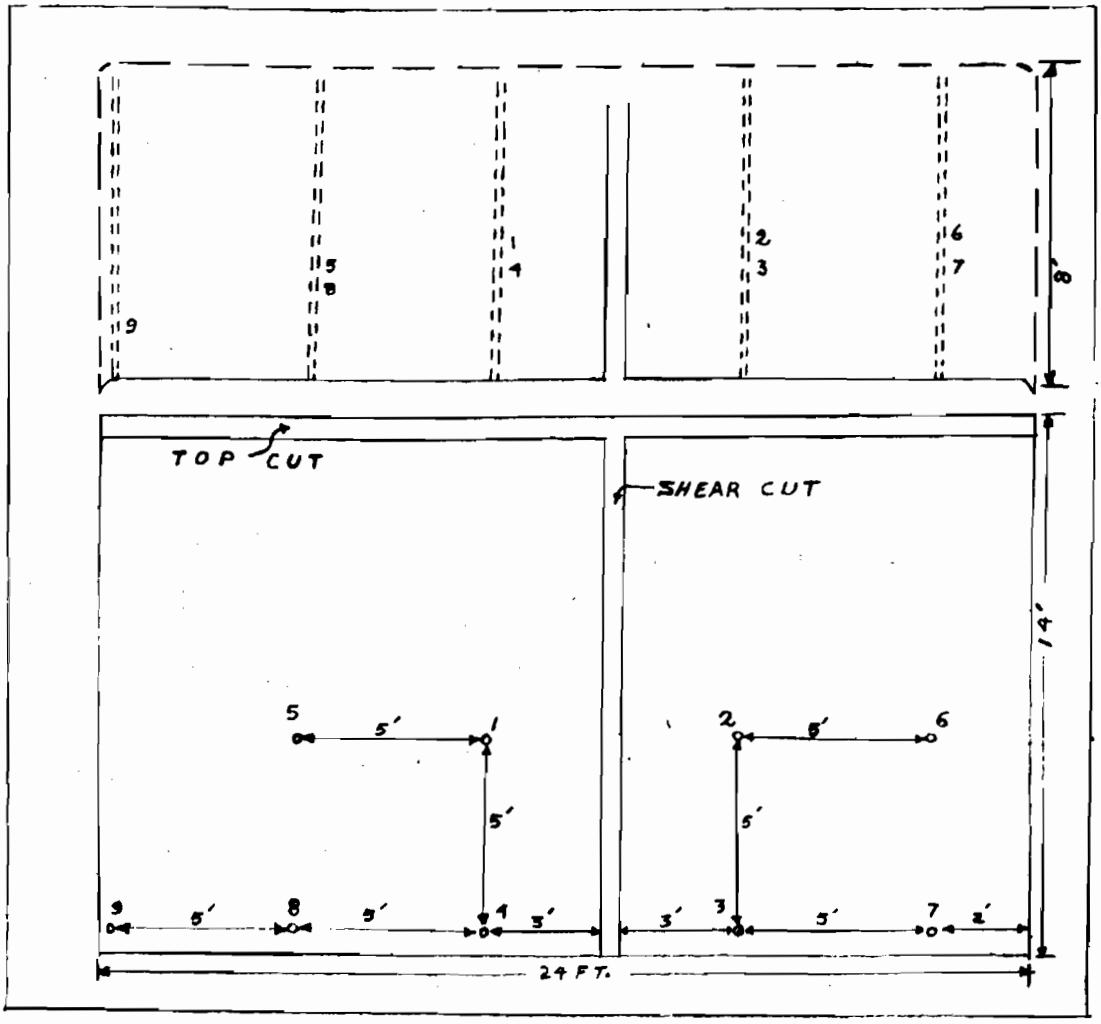


FIG. 14 – DRILLING PLAN. NUMBERS DENOTE ORDER OF SHOOTING. D.O. CLARK MINE.

along the desired line. Up to 60 percent of the timbers are recovered and reused for further supporting.

Face Preparation.-- The face is prepared in the order indicated in Figure 14. Both top cutting and shearing are employed. Top cutting is done at or near the top of the seam, leaving enough top coal to help support the roof. Shearing is done in the center of the face to relieve the coal burden and to make the blasting easier. The depth of cutting and shearing is from 8 to 9-ft. For this purpose, the rubber tired shortwall cutting machines are used.

Beside the cuts, 9 holes are drilled at the face with a Chicago "Little Giant" drill and McLaughlin augers using removable bits. The depth of the holes are 8½-ft. They are loaded with permissible sheathed explosives and are tamped to the collar with dummies of incombustible material. One hole is shot at a time, followed in the sequence indicated in Figure 14. All holes are drilled normal to the face.

Haulage.-- Transportation of coal at the D.O. Clark Mine, No. 7 seam, is accomplished by a combination of track haulage and belt conveyor. For transporting the men and the material, rope haulage is used on the Main Entry Slope.

Loaded 4-ton mine cars are assembled into trips in the strike entries by 15-ton trolley locomotives. These locomotives can pull from 24 to 30 loaded cars per trip to the rotary dump station at the slope. The belt takes the coal

directly to the tipple.

In shaker territories, the coal is loaded from conveyors into the cars on the haulways. In mobile loader sections, the shuttle cars dump the coal onto shakers and then the shaker delivers it to the cars in the haulway.

Ventilation.-- Each one of the four seams are ventilated individually by separate fans. The fresh air for the No. 7 seam is supplied by a 50 hp fan, at the rate of 120,000 CFM against a 2-inch water gauge.

Ventilation in room work or beyond the farthest crosscuts is maintained with an auxiliary blower fan (2 hp). The tubing of the fan is kept within 20-ft. of the working faces at all times.

CHAPTER VII

STANSBURY MINE

SEAM NO. 1

The Stansbury Mine, a property of the Union Pacific Coal Company, is situated 7 miles north and 2 miles east of Rock Springs, Wyoming. This mine was developed during the war for the purpose of meeting the increased demands of the Union Pacific Railroad for fuel. The Stansbury Mine is, at present, producing 4,000 tons a day from three seams. The mine is largely in the development stage.

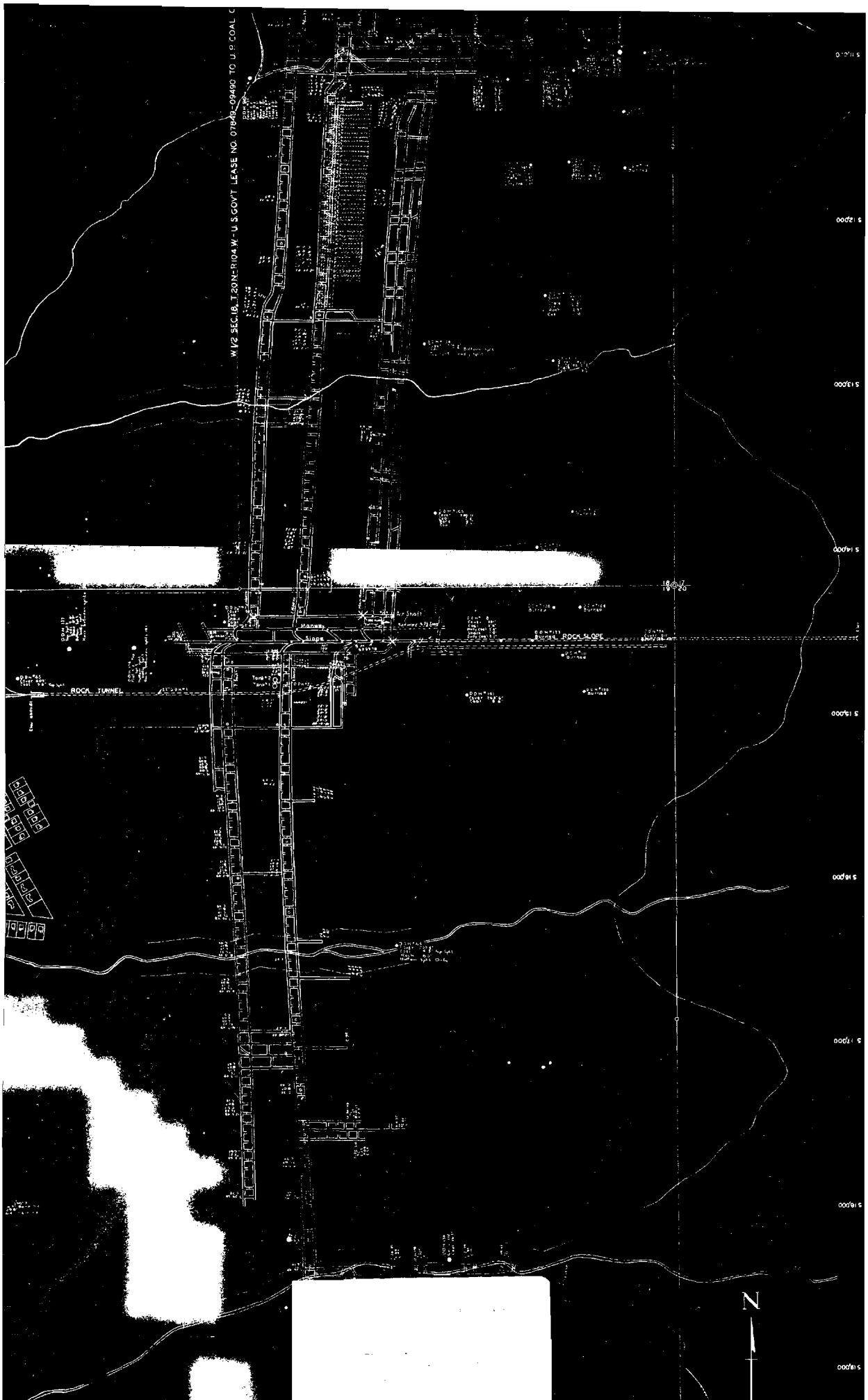
Seam Characteristics and Geology.-- There are three seams in this area that are separated with interbedded layers of sandy shale. The thickness of these layers vary from 135 to 150-ft. The coal is bituminous in rank, and of Cretaceous age. The seams dip 9 percent to the east, and range in thickness from 5 to 17-ft.

There are no faults of great importance. The roof is of sandy shale, sandstone, or limestone. The coal itself is friable; cleats and cleavages are well pronounced. In the No. 1 Seam, there is a rock parting from 1 to 2-ft. in thickness, which contaminates the coal mined. In places where the coal is too high, or the roof is too weak, up to 5-ft. of top coal is left in order to keep the entries at a desirable height or to protect the men against roof falls.

Mine Layout.-- The mine is entered through a rock tunnel which is driven against the pitch of the seams on a level grade. This tunnel intersects the No. 3 Seam (first upper seam) at a point 2,300-ft. from the portal, the No. 1 Seam (second upper seam) at 3,050-ft., and the No. 7½ Seam at 3,800-ft. from the portal (See Fig. 15).

At the point where the rock tunnel hits the No. 1 Seam the Dip Slope is driven down the dip. This dip slope leads to the Main Haulage road and further down to the entries which are driven on strike. The Dip Slope is a single entry until it hits the Main Haulage road. Then it is driven as a four entry system. The slopes are on 55-ft. centers, each being 12-ft. wide. The Main Haulage and other strike entries are driven at right angles to the slope and are on 50-ft. centers, being 14-ft. wide. Sub-slopes are driven parallel to the Dip Slope at approximately 300-ft. intervals.

Mining Method.-- The retreat system of room and pillar method of mining is accomplished with the use of duckbill equipped shaking conveyors and mobile loaders. In the development work in coal all downgrade places were driven with track-mounted universal type cutting machines and Joy loaders, upgrade places with shortwall cutting machine and shaking conveyors. The strike entries are driven with shaking conveyor units. From these entries the rooms are started in pairs to the rise. Pillar extraction is followed from the end of the entries toward the Dip Slope. The major portion of the mining


W 1/2 SEC. 18, T 20 N - R 104 W - U.S. GOVT LEASE NO. 07049-09490 TO U.S. COAL
ROCK TUNNEL
Manway
Slope
ROCK SLOPE
N

equipment consists of shaking conveyor units, together with shortwall mining machines and electric drills of hand hold or post mounted type.

The pillar extraction system and timbering is just the same as described before in D. O. Clark Mine. These and other similar operations are standardized by the Union Pacific Coal Company.

Face Preparation.-- The face is prepared in the manner shown in Figure 16. It is undercut with a cutting machine to a depth of 9-ft. Above the undercut 9 holes, 4 in the center row and 5 on top row are drilled to a depth of 8.5-ft. The holes are loaded with 3-4 sticks of permissible, sheathed powder, and are tamped to the collar with the dummies. One hole is shot at a time, in the order shown in Figure 16. All holes are drilled normal to the face.

Haulage.-- Transportation in Stansbury Mine is accomplished by a combination of track- and rope-haulage. Mine cars of 4-ton capacity are loaded in the strike entries directly from the shakers or shuttle cars. These loaded cars are gathered by electric locomotives and are hauled to the slope partings. Then they are hoisted up to the rock tunnel partings.

In the sub-slope sections, the cars are gathered in the same manner and hoisted up to the Main Haulage road partings. They are transported from there along the Main Haulage Road to the Dip Slope. From the top of the Dip Slope the trips are

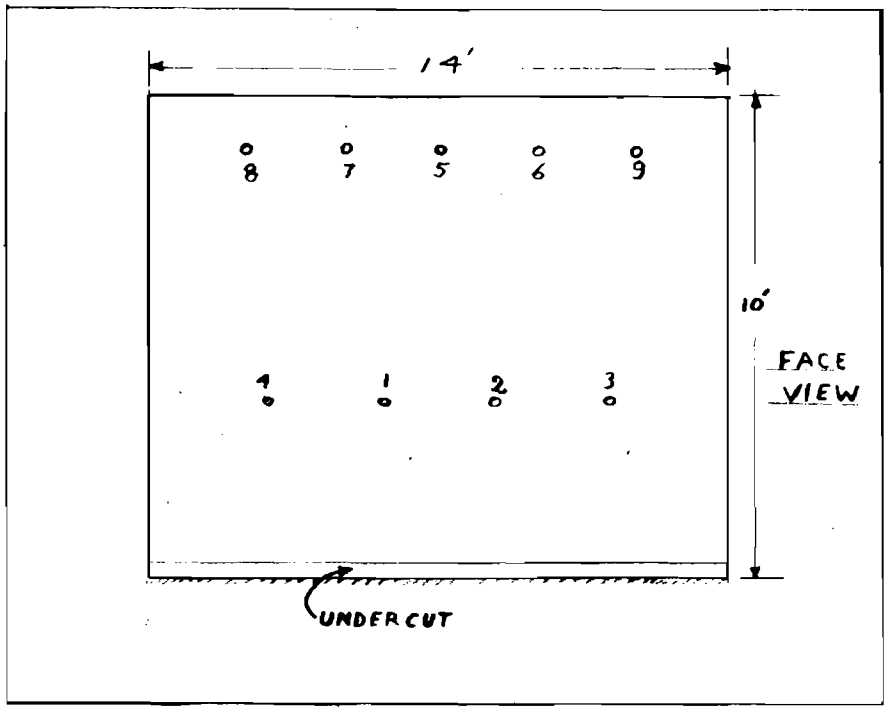


Fig. 16 – Drilling Plan in Stansbury Mine. Numbers Denote Order of Shooting.

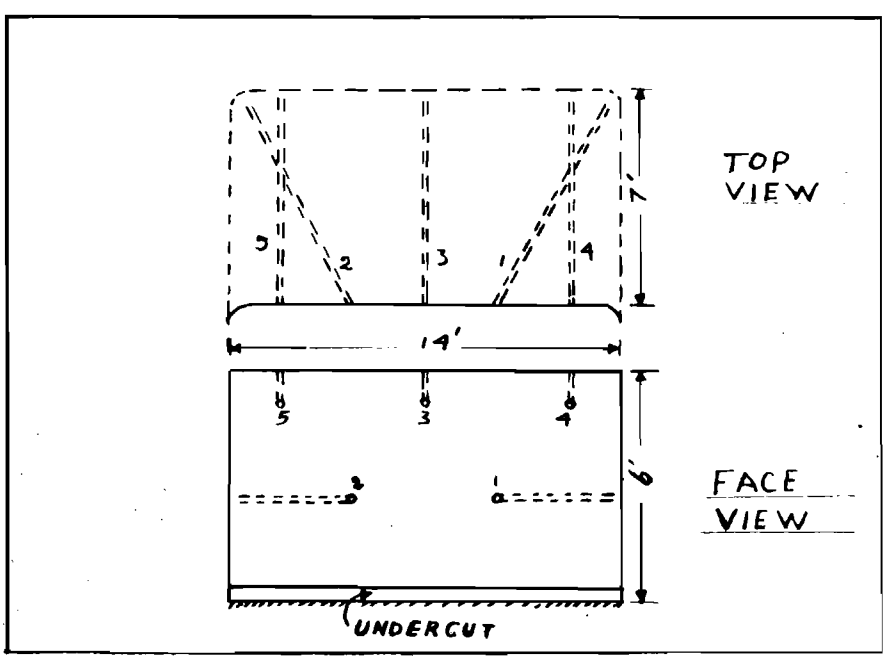


Fig. 18 – Drilling Plan in Reliance Mine. Numbers Denote Order of Shooting.

taken through the rock tunnel. The main line haulage is accomplished by the use of 13-ton trolley locomotives.

Ventilation.-- The fresh air is supplied to the mine by two Aerodyne fans that exhaust at a rate of 100,000 cubic ft. of air per minute. The fans are powered by 25 hp motors and operate at a 1-inch water gauge.

The permanent stoppings and overcasts are airtight and are constructed of concrete. At present the gas percentage is not too high. Ventilation in room work or beyond the farthest crosscuts is maintained with an auxiliary, blower fan and the tubing is kept within 20-ft. of the face.

CHAPTER VIII

RELIANCE MINE NO. 11 SEAM

The Reliance Mine of the Union Pacific Coal Company is situated 5 miles north and 6 miles west of Rock Springs, Wyoming. U.S. Highway No. 187 passes about 4 miles west of the town of Reliance.

The No. 11 seam of the mine employs 220 men underground, and produces about 2,100 tons of coal per day on a two-shift basis.

Seam Characteristics and Geology.-- In the Baxter Basin the Reliance Mine recovers a coal bed 7-ft. thick, which is known as No. 11 Seam. About 125 ft. above this is the Reliance No. 7 Seam, which is also being mined by the same company. The interbedded layer between the two seams consists of sandstone and sandy shale. The upper seam (No. 7) is being retreated ahead of No. 11 Seam.

The coal in this area is of bituminous rank, and of Cretaceous age. The seam dips as much as 16½ percent to the west. The strata above the seam consists of sandy shale and forms a weak roof. The bottom is the same. There is a 12-in. thick rock parting in the seam about 18-in above the bottom. It is usually left as part of the floor, but where the coal seam gets thinner this parting is mined to get enough clearance. Although the seam is only 7-ft. thick, from 1 to 1.5-ft. of top coal is left in development work for protection

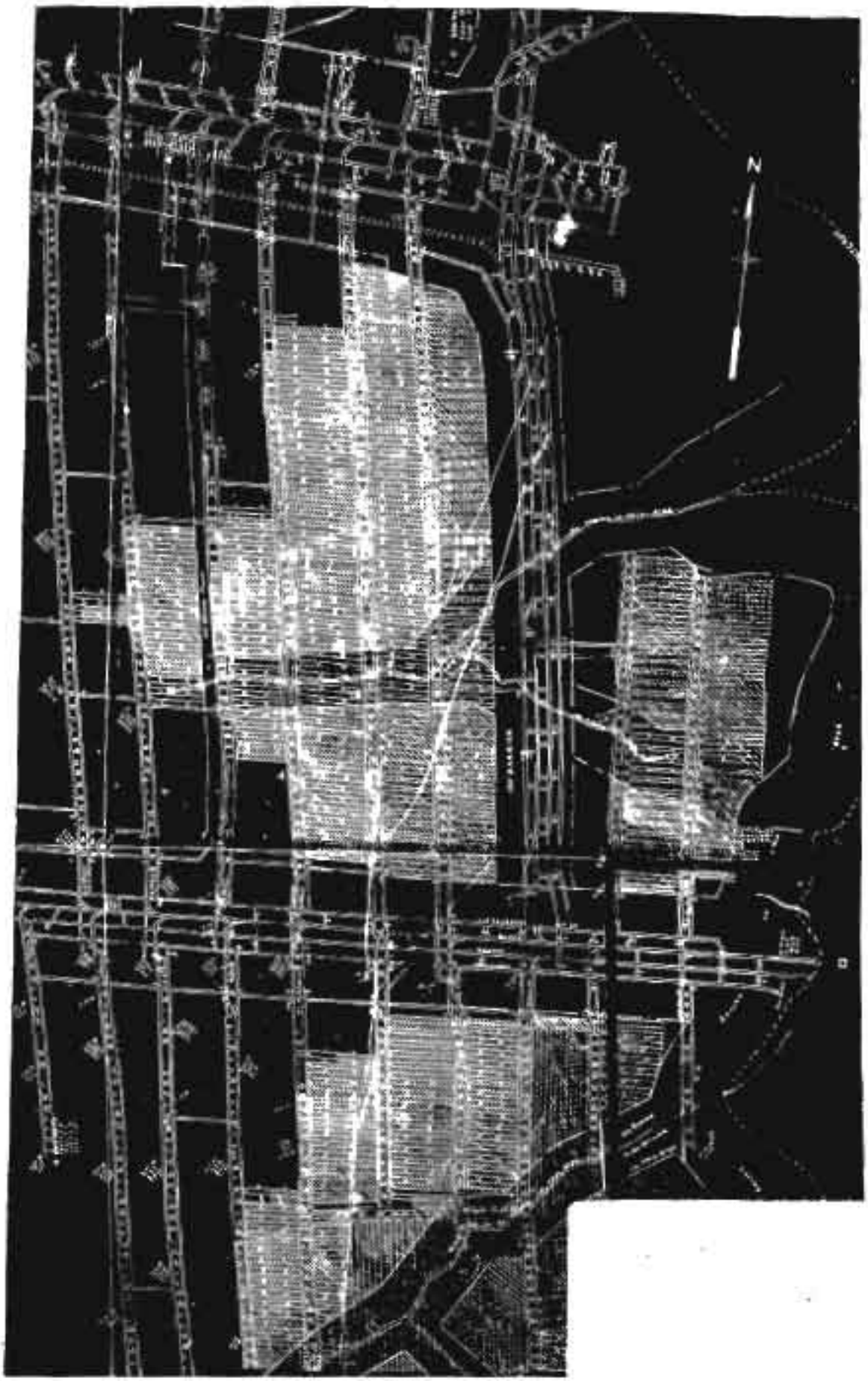
against roof falls.

Because of the bad roof conditions, close timbering is used. The rate of gas liberation is low and therefore the mine is classed as non-gassy.

Mine Layout.-- From the surface, a rock tunnel is driven against the pitch of the seam on a level grade. This intersects the No. 11 Seam at a point 2,200-ft. from the portal. In order to intersect the seam at two points, the rock tunnel splits (Y-shaped) at a 100-ft. distance from the seam. This is done to obtain convenient haulage; i.e., the trips from the north and south side of the mainline enter into the tunnel separately (See Figure 17).

The Main Haulage Road runs in a north-south direction and consists of four entries. These are driven on 50-ft. centers and are 12-ft. wide. From the mainline, four sets of slope entries are driven down the dip of the seam at 3,800-ft. intervals and on 50-ft. centers. These are 12-ft. wide. The hoists are installed up above the main line partings for the rope haulage. The strike entries (double entry system) are driven at approximately right angles to the slopes at 300-ft. intervals.

Mining Methods.-- The retreat system of room-and-pillar method of mining is accomplished with the use of duckbill equipped shaking conveyors and mobile loaders. In the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development work in coal all downgrade places are driven with track-mounted universal cutting machines and Joy loaders; upgrade places with shaking conveyors and shortwall cutting machines. The major piece of mining equipment is the shaking conveyor. The strike entries are driven by a pair of shaking conveyor units. They are then turned on the pitch line for room-and-pillar extractions.

Because this mine is also operated by the Union Pacific Coal Company, the same standardized system for pillar extraction is employed (See Fig. 11).

Face Preparation.-- On a 6-ft. high and 14-ft. wide face, a 7-ft. undercut is made with a shortwall cutting machine. About 5 holes are drilled with a Chicago " Little Giant" drill and McLaughlin auger, using removable bits, to a depth of 6.5-ft. The number of the drill holes is increased with the size of the face. The holes are charged with permissible sheathed powders, and tamped to the collar with dummies. One hole is shot at a time in the order shown in Figure 18.

Haulage.-- Mine cars of 4-ton capacity are loaded in the strike entries directly from the shakers. These are gathered by 8-ton locomotives and hauled to the partings of the dip slopes. Then they are hoisted up to the top end of the slope and lowered to the mainline partings. These cars are hauled to the surface through the rock tunnel by 15-ton trolley locomotives.

The track on the main haulways is laid with 80-lb. rails. The secondary track in strike entries and slopes is of 60-lb. rails. The tracksare on a 42-in. gauge.

Ventilation.-- Two exhaust fans which are located on top of the air shafts supply the fresh air to the mine. While one fan on the first dip side exhausts the air from the first dip section, the other fan on the second dip side exhausts the air from that particular section. In this way the ventilation is well balanced in the mine.

Permanent stoppings and overcasts are airtight and are constructed of concrete. Brattice curtains are used temporarily on the crosscuts. Ventilation in room work or beyond the farthest crosscuts is maintained with auxiliary blower fans.

CHAPTER IX

IMPERIAL MINE

The Imperial Mine is owned by the Imperial Coal Company. It is located about three miles east of Erie, Weld County, Colorado, about 28 miles north of Denver, Colorado. Highway 185 passes a quarter of a mile to the east of the mine.

The mine produces about 800 tons of coal per day, and employs an average of 80 men underground. All tonnages come from shaking conveyors.

Seam Characteristics and Geology.-- In the Denver Basin, the Imperial Mine recovers a lignite seam known as the Laramie Formation. The coal seam lies under a cover of 280-ft. which is composed of slate and soapstone. This forms a weak and tender roof which calls for narrow openings and good supports. Faults, if any, are not of great importance. The bottom is of soapstone and sandstone, with the main bottom of sandstone. The thickness of seam varies from 6 to 10-ft. Some 18-in. of coal over a natural parting is left to protect the top. The coal seam dips about 1 to 1.5 percent to southeast. Coal, in this mine, may be said to be free from impurities.

Mine Layout.-- For mine layout see Figure 19. The mine is entered through a double compartment, 283-ft. hoist shaft, which is driven from the surface down to the bottom

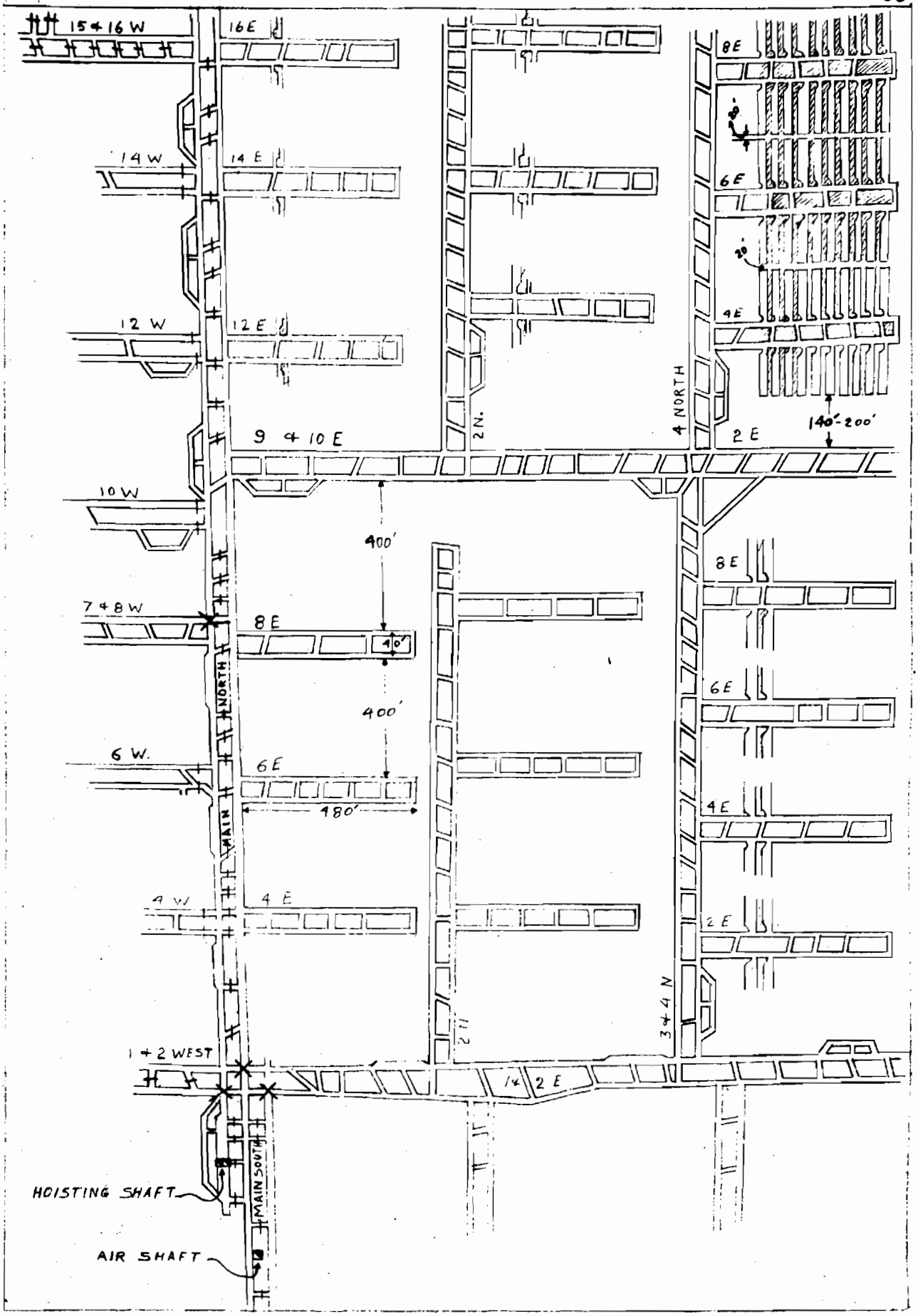


FIG. 19 - SHOWING THE MINE LAYOUT OF IMPERIAL MINE OF IMPERIAL COAL CO. AT ERIE, WELD COUNTY, COLO.

(Courtesy of Imperial Coal Company)

of the coal seam. This shaft serves for hoisting men, material, and coal. From the hoisting shaft, the main north and south entries are driven on 50-ft. centers and are 10 to 11-ft. wide. The mine, as a whole, is a double entry system, including the side entries. At approximately a 90 degree angle to these north and south main entries, east and west entries are driven. Extending from these are north and south cross entries. All entries in the mine are from 10 to 11-ft. wide and are on 50-ft. centers. The crosscuts also are from 10 to 11-ft. wide, but they are driven on 60-ft. centers.

Mining Method.-- The room-and-pillar system of mining is successfully employed. Care in the early stages of mining is reflected in the straight entries and very regular panel development. By about 1937, the room-and-pillar work in the panels was well developed, leaving some virgin coal in the barriers. The latter contained appreciable amounts of coal and were economically mineable. So the shaking conveyors were started in the barriers as well as in the room work.

At present, all tonnages come from shaking conveyors. In the mine 14 shakers are employed. These are equipped with a 6-ft. long and 30-in. wide pan. After the face is undercut, the pan is placed under the coal to within 6-in. of the back of the undercut, and then the center is shot down on it. In this way, the conveyor can shake out the coal with a minimum

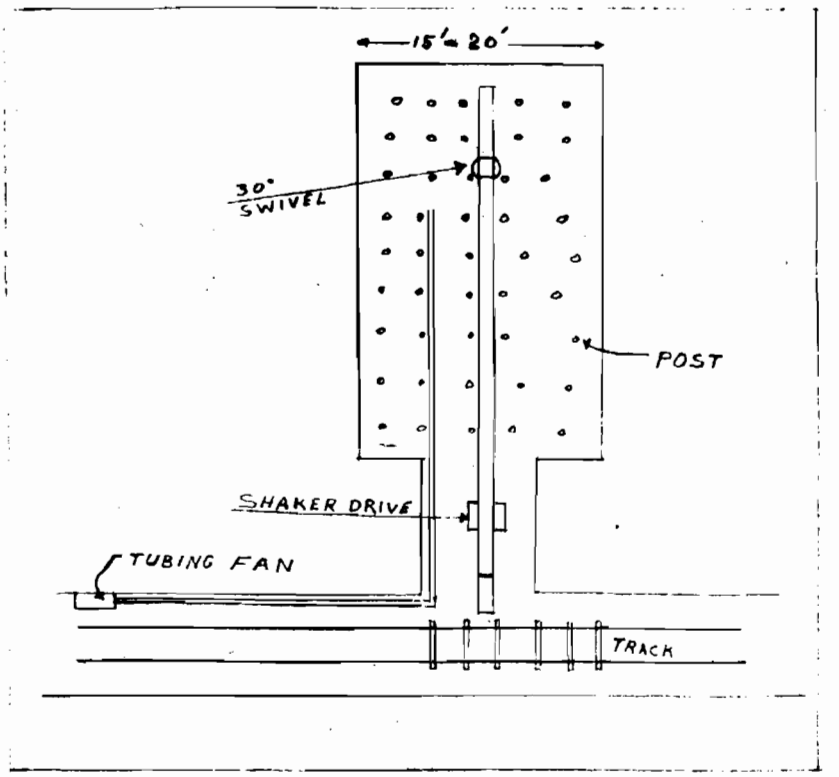


FIG.20 SHOWS TIMBERING AND ROOM WORK IMPERIAL MINE.

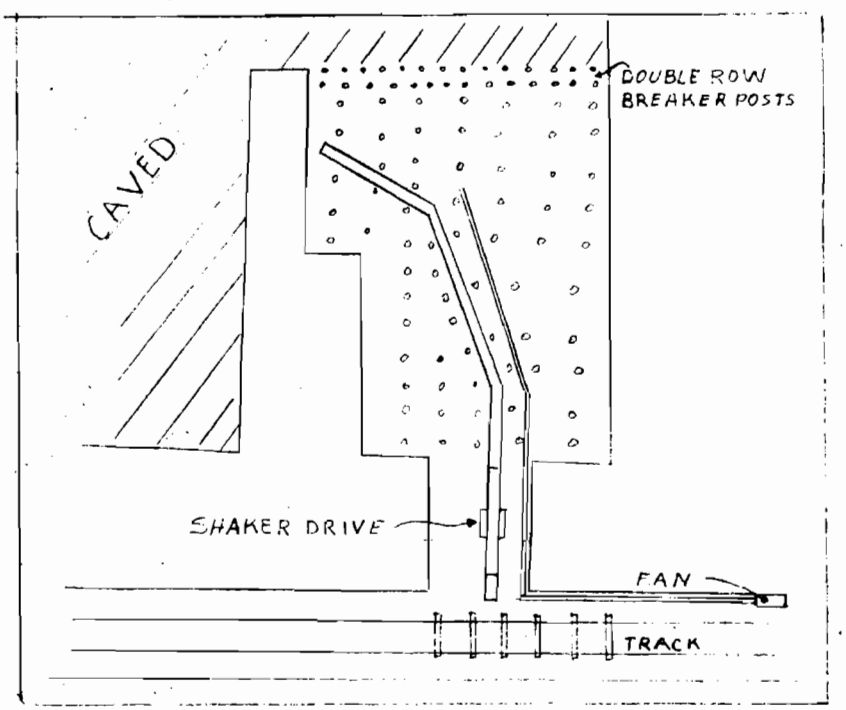


FIG.21- PILLAR PULLING WITH SHAKER AT IMPERIAL MINE.

requirement of hand shoveling.

Upon completion of the panels, break entries are driven off at 90 degree angles to the cross entries. From each side of the break entries, the rooms are driven off at right angles. The rooms are 200-ft. in depth and are on 23-30-ft. centers. In the panels, 140-ft. barrier pillars are left to be mined afterwards. For protection against spontaneous combustion, a 20-ft. pillar is left permanently between the bottom ends of the rooms. This prevents the air from circulating through the goaf after the pillars are removed. For illustration, see Figure 19.

For pillar extraction the "open-end" system with the use of shaking conveyors has proved efficient and safe. The recovery, including barrier extraction, is as high as 92 percent. In room and pillar work, double sets of timbers are placed, starting from the room neck and running to the end of the room (See Figure 20). While drawing pillars (Fig. 21) at the end of the room a breaker row of timber is set to cut off the cave.

Barrier Extraction.-- After room and pillar work is completed, the barrier pillars are extracted. Figure 22 illustrates the complete extraction of the barrier on one side of an entry and the partial extraction on the other. This leaves a fire pillar.

Face Preparation.-- With a shortwall cutting machine

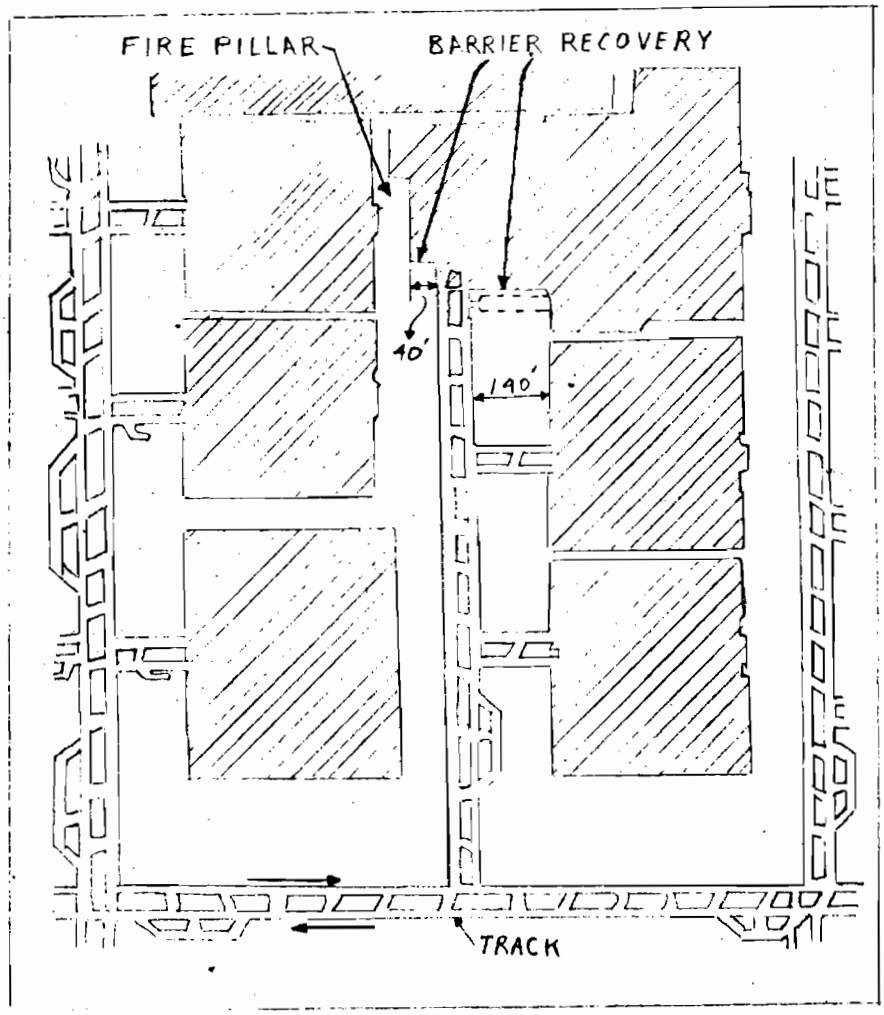


FIG. 22 - SHOWING BARRIER RECOVERY IN IMPERIAL MINE. RIGHT IS BEING COMPLETELY REMOVED. LEFT PARTLY REMOVED, LEAVING A FIRE PILLAR. (COAL AGE, OCTOBER, 1946).

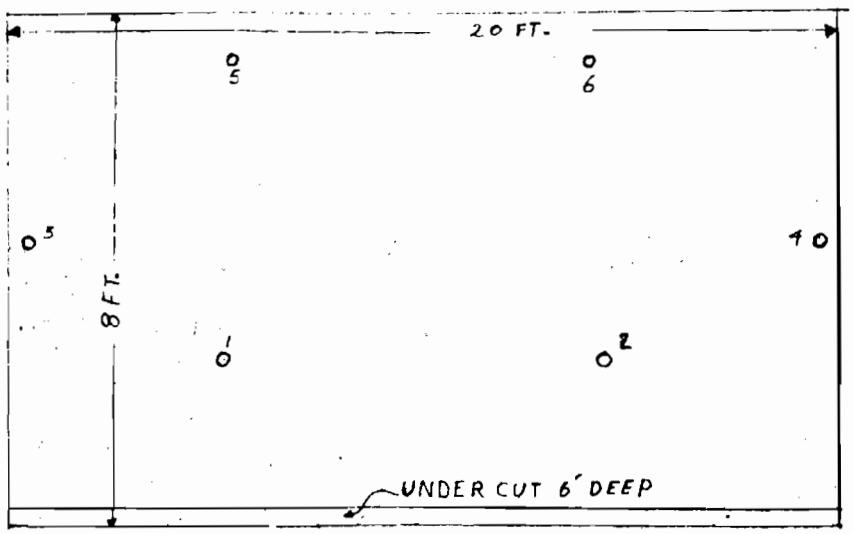


FIG. 23- SHOWS THE FACE PREPARATION AT IMPERIAL MINE

a 6-ft. undercut is made (Fig. 23). The holes are drilled normal to the face for blasting with the permissible explosives. When cardox tubes are used, the top holes are dropped a little and angled up. Drilling is done with auger type, portable drilling machines.

Two kinds of charges are being used, permissible explosives and cardox tubes. The latter is used only when large lump coal is desired. In using permissibles, each hole is charged with 3 sticks of powder and is tamped to the collar with dummies.

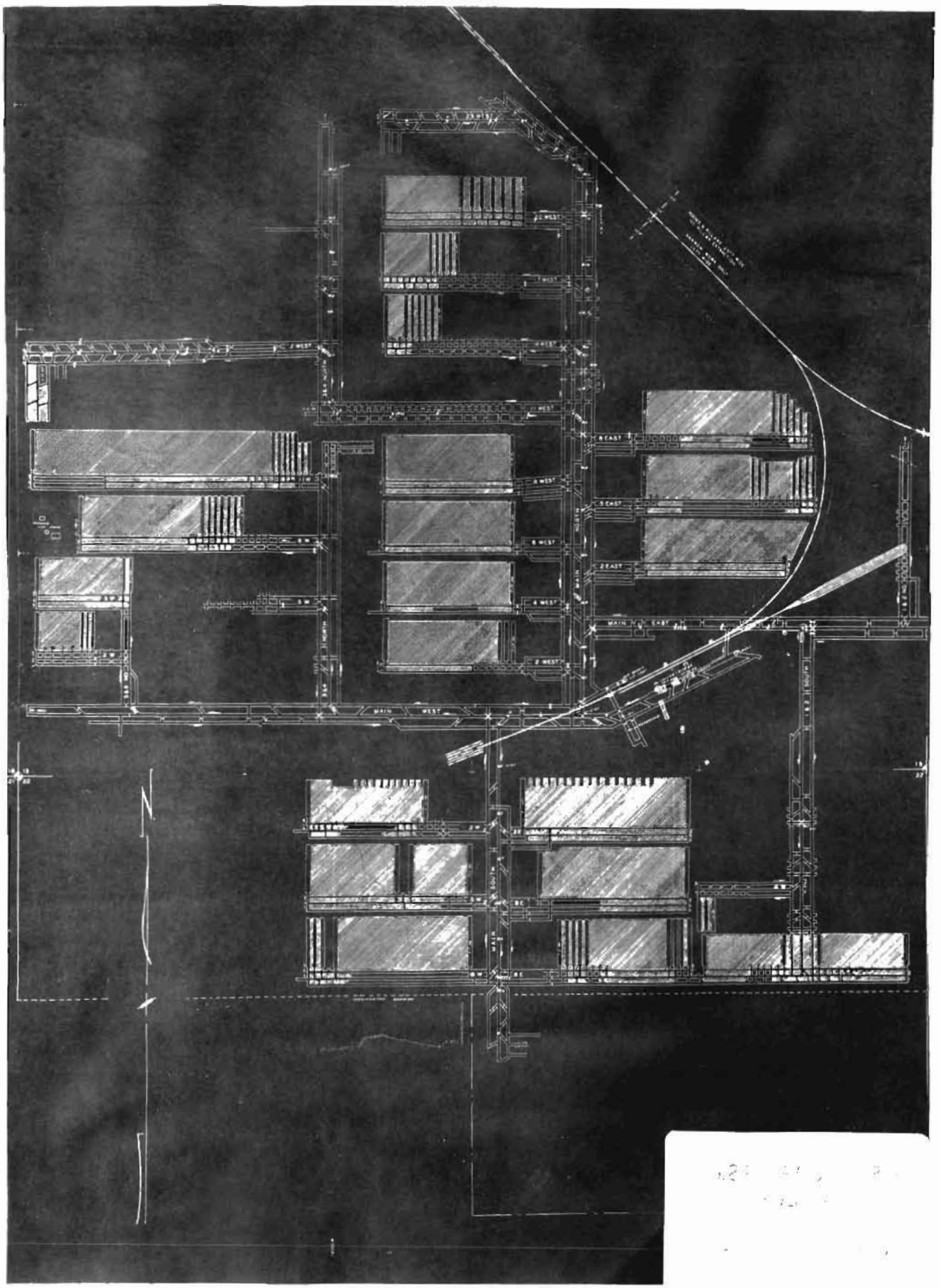
Haulage.-- Mine cars of 1.5-ton capacity are loaded in the cross entries from the shakers. These are then gathered by 6-ton battery locomotives and delivered to 8-ton trolleys on the mainline. The loaded trips are hauled to the shaft station and empties brought back.

The transportation in this mine is accomplished by a combination of track-haulage and shaft hoisting. The natural conditions of the seam make it possible to have smooth running transportation system.

Ventilation.-- One fan at the surface supplies fresh air to the mine at the rate of 100,000 CFM. There is another fan next to this for emergency purposes. This has a capacity of 70,000 CFM. In the mine an average of 1.5-in. water gauge is obtained.

Auxiliary blower fans are used to maintain the fresh air

in room work or beyond the farthest crosscuts. The tubing is kept within 20-ft. of the face.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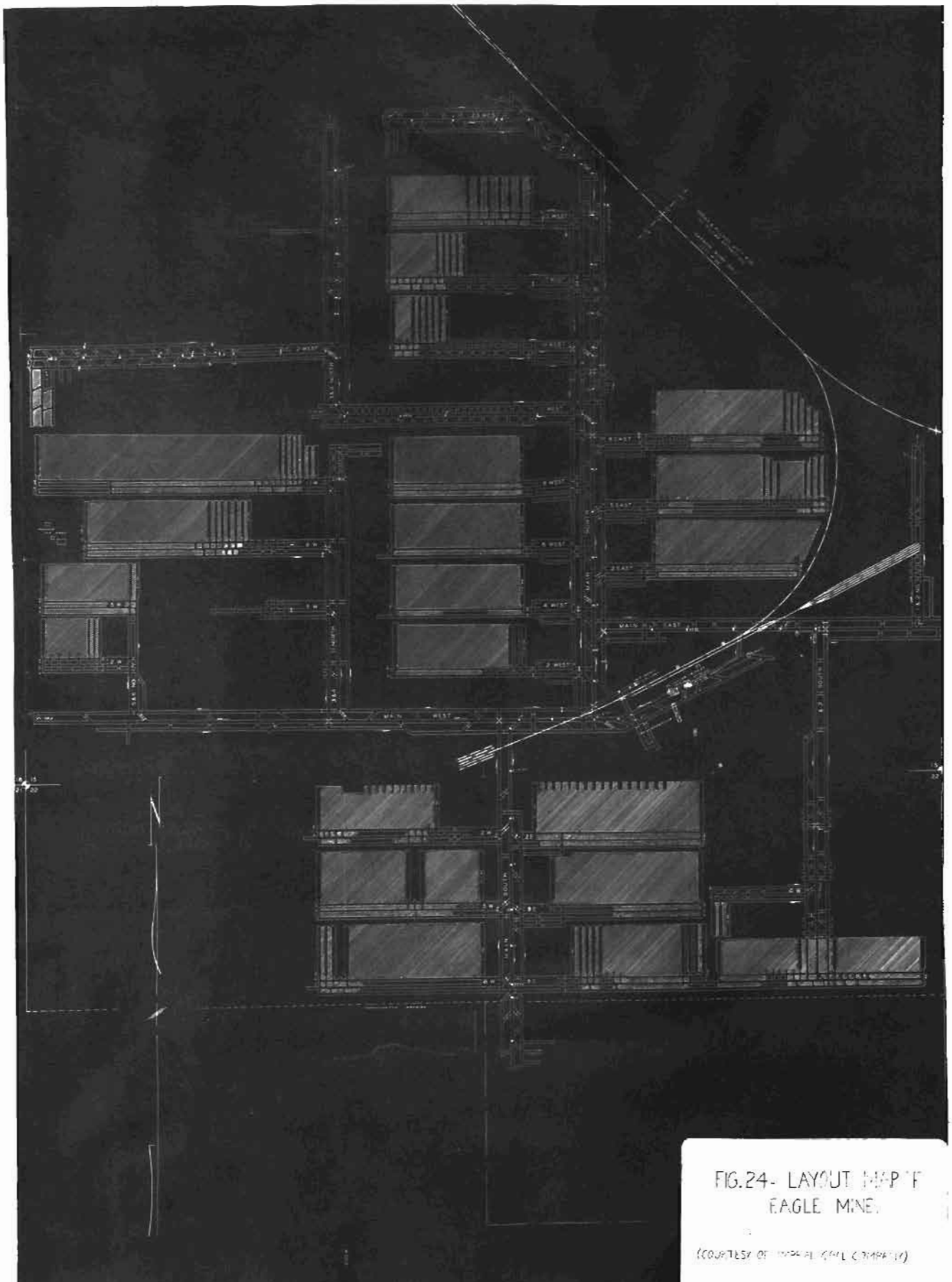

FIG. 24- LAYOUT MAP OF EAGLE MINE.

(COURTESY OF [illegible] COAL COMPANY)

CHAPTER X

EAGLE MINE

Adjacent to the Imperial Mine and to the south is the Eagle Mine, which is also owned and operated by the Imperial Coal Company. The Eagle Mine is, at present, producing about 1,600 tons of coal in a two-shift day and employing an average of 110 men underground.

Seam Characteristics and Geology.-- The Eagle Mine is also in the Denver Basin and mines the lignite coal seam of the Laramie Formation. The average cover is about 370-ft. and consists of sandstone and shale. This forms a rather weak roof especially where the shale content is high.

The seam is flat and ranges from 7 to 10-ft. in thickness. The coal is not overly friable. About 2-ft. of top coal is left in development work where the thickness of coal is great enough to provide sufficient clearance; otherwise the top coal is ignored.

There are no faults in the area of any importance. The seam itself is clean; and free from rock partings and impurities.

Mine Layout.-- The Eagle Mine is entered through a double compartment, vertical shaft. The depth of shaft from surface to the bottom of seam is 369-ft. This shaft serves to hoist men, coal and material. From the shaft station, the

Main North and Main West entries are driven. North and west entries are driven off the Main entries at right angles forming blocks of panels. In these panels cross entries branch off the above north and west entries at 300-ft. intervals. They are about 1,100-1,200-ft. long, leaving a 200-ft. barrier (See Fig. 24).

From these cross entries the rooms are driven off at right angles and on 40-ft. centers, each room being 12-ft. wide and 250-ft. long. The slants (crosscuts) are on 60-ft. centers and are also 12-ft. wide.

The whole mine is a three entry system (except some of the cross entries). All entries are on 50-ft. centers and are 10-ft. wide.

Mining Method.-- In the Eagle Mine the retreat system of room-and-pillar method is accomplished with the use of trackless mobile loaders and shaking conveyors. The mine was originally developed with shakers alone, but today these have been totally replaced by trackless mobile loaders. The new equipment includes 14 BU Joy loaders, shuttle cars, 7B Sullivan cutting machines, and portable auger drill machines. All of this equipment is powered by permissible cable reel.

Room and Pillar Work.-- Upon completion of development work, the rooms are driven perpendicularly off the cross entries to a maximum depth of 250-ft. The rooms are 12-ft. wide and on 40-ft. centers. The rooms in this mine are

narrower than those in the Imperial Mine and need no timbering during development work. Two sets of timbers are set in the rooms while pillars are being extracted, and a breaker row is placed to cut off the cave.

The pillars are pulled in the same manner as in the Imperial Mine, which was described previously. The only difference between these two is that in this mine mobile loaders are used instead of shaking conveyors. At present the barrier pillars are not being extracted.

Face Preparation.-- For an illustration of face preparation, Fig. 18 can be used. On a 12-ft. wide and 8-ft. high face three top and two center holes are placed. The undercut is 8-ft. deep and the holes are 1/2-ft. shorter than the undercut. The top holes are straight, but the center holes are angled up toward the center of the face when cardox is used. For blasting with powder, all of the holes are drilled straight.

After the undercut is completed and the holes are drilled, it is shot either by cardox or by permissible sheathed powder. When powder is used, the holes are charged with 2-3 sticks and tamped to the collar with dummies.

Haulage.-- Transportation is accomplished by track-haulage and shaft hoisting. The cars are loaded by shuttle cars in the cross entries and gathered by small trolley locomotives which deliver them to the main entries. The trips

from the main entries are hauled to the shaft station partings by 10-ton trolley locomotives. They are then hoisted up to the surface. A double compartment shaft is used, and while the loaded car is hoisted in one compartment, the empty car is lowered in the other.

The tracks are laid on 36-in. gauge, and the cars are of 2-ton capacity. All of the locomotives, ranging from 4 to 10-ton, are of the trolley type.

Ventilation.-- Fresh air is supplied to the mine by an exhaust fan at the rate of 116,100 CFM through the shaft. There is another fan adjacent to this one for emergencies. The main fan is powered by a 40-hp motor and maintains a pressure of about 1.5-in. water gauge.

Ventilation in rooms or beyond the farthest crosscut is maintained with an auxiliary blower fan. The tubing of the fan is being kept within 20-ft. of the face. The mine is non-gassy.

PART TWO:

COMPARISONS

* * *

CHAPTER XI

CRITERIA OF COMPARISON

Before comparing the various types of mining methods that have been studied previously, let us define what is meant by the best one. The best mining method is the one which is the safest and most economical with the highest recovery percentage.

Even under the best of conditions the mining industry is dangerous, therefore safety for the men should be one of the prime considerations in choosing a particular method. It should obviously be economical since its purpose is business. The development of our civilization and industry rests directly upon fuel consumption of which coal is the main resource. On the other hand, mining is a wasting asset, and the coal resources are running short. Thus, the method chosen should yield the highest recovery percentage.

Last, but not least, there is another important factor that we are confronted with today, namely, speed. Industry is growing from day to day, and so is the need for fuel. Consequantly, the method used should give the highest possible output per day. This last factor might be considered economically in two respects: (a) the life of the mine is going to be shortened, making a quick return of capital invested possible, (b) the production per man rate is increased and thus the mining cost is decreased.

To be able to establish a mine as described above, the following conditions in that particular area should be

thoroughly studied:

(1) Natural or physical conditions of cover overlying the coal bed (main and immediate roof separately).

(a) Thickness

(b) Type of rock or rocks

(c) Presence of hydrostatic pressure

(d) Location of gulch and creek, if any, on the surface.

(2) Natural or physical conditions of the coal bed itself.

(a) Thickness

(b) Dip of the seam

(c) Structure, cleats and cleavage, friable or massive.

(d) Strength of coal

(3) Character of floor; whether or not it heaves

(4) The value of surface as compared with the value of coal in place. The method of pillar extraction used might be cheap for mining, but may result in subsidence on the surface.

Inasmuch as no two areas have exactly the same conditions, no definite rules can be set forth for choosing a mining method. A detailed study of each area or mine is therefore necessary and conclusions drawn from the data obtained.

CHAPTER XII

COMPARISON

General.-- All of the mines that are described in the first part of the thesis are using the room-and-pillar system of mining. The mines are developed initially with either shaking conveyors, or a combination of shaking conveyors and mobile loaders. Upgrades or raises are usually driven with shakers. The slope entries, as downgrades, are driven with track-mounted mobile loaders combined with rope haulage. In driving level entries and rooms either shakers or mobile loaders are used.

With the shakers, rooms are driven at a 90 degree angle to the entry. With mobile loaders, the angles range from 35 up to 60 degrees to allow shuttle cars and mobile loaders to maneuver easily. These angles may also be affected by the structure and the pitch of the coal. Generally, the depth of rooms, in either case, does not exceed 300-ft. This might be called the "effective distance" for the transporting equipment used.

Mining with Hand Loading.-- Direct hand loading in coal mines, especially in this country, became obsolete a long time ago. It still might be applicable in countries where labor is cheap enough not to warrant buying expensive mining equipment. Today hand shoveling is only used in cleaning up purposes.

Shaking Conveyors.-- For many years, the shaking conveyor was the major piece of loading equipment in the coal mines. Now they are being replaced by mobile loaders. The tendency of replacing shakers in the Utah mines is greater than in Wyoming and Colorado (with regard to those visited).

At present, the Sunnyside Mine of Utah Fuel Company is using mobile loaders, with the exception of two duckbill equipped shakers and one continuous miner. This mine averages 18.6 tons of coal per man. The Castle Gate Mine of the same company uses 12 shakers and only a few mobile loaders, and averages 9.0 tons of coal per man. The Kenilworth Mine of the Independent Coal and Coke Company employs only one or two shakers and the rest are mobile loaders. They get an average output of 10-11 tons per man. The Geneva Coal Mine, the newest and most modern of all, employs a wide range of loading and transferring equipment, including various types of mobile loaders, shakers, and belt and chain conveyors. This mine has an average output of 8 tons per man. This figure is not its true production rate, since the coal is not being mined to full capacity.

The Union Pacific Coal Company's mines in Wyoming, such as Reliance, Stansbury, and D. O. Clark, are mainly developed with shaking conveyors. Today few mobile loaders are being brought in. These mines range in the rate of output per man from 8 to 10 tons.

The Imperial Coal Company's mines in Weld County, Colorado, such as the Imperial and Eagle, are good examples for comparing shaker and mobile loader operations. These two mines are under the same supervision and have almost the same natural conditions. The coal in both is lignite with nearly the same thickness and structure. The main difference is that the Imperial Mine uses shakers solely, working mainly on barrier extraction under tender roof condition. This mine gives an average output of 10 tons of coal per man. On the other hand, the Eagle Mine employs only shuttle cars and mobile loaders in rooms and development work. This mine gives an average output of 15 tons per man.

As can be seen, the mobile loaders generally give a higher output per man than do shaking conveyors. Of course, not only the loading equipments, but many other factors must be weighed. These factors are the roof condition, the coal itself, the behaviour of the floor, the type of work (development, pulling pillar, or extracting barriers) and the supervision.

Main objections to the shaking conveyors are as follows:

(1) More skilled work and hand loading is needed (about 60-70 percent of mined coal is removed with duckbills or pans, but the rest is shoveled by hand).

(2) Difficult and slow to move from one place to the next, and therefore, time consuming.

(3) Desired speed in removing coal is not met.

Contrasted with these disadvantages are the following

advantages:

(1) Less operating power consumed than with the mobile loaders.

(2) Greater efficiency is realized in driving entries and raises.

(3) Its initial cost is low.

(4) Hand picking (cleaning) is possible when rock parting in the coal seam is mined.

(5) In places where the floor heaves, shaker can be used to better advantage than mobile loaders.

Track-Mounted Mobile Loaders.-- This type of equipment is almost always used in the driving of entries and slopes where tracks are needed. In loading, it cleans the face properly, but unfortunately, maneuvering loaded and empty cars is a big problem in its operation. That is, after one car is loaded, there is a delay until it is hauled to the parting and an empty one brought back. Shakers are superior in this respect, but are not good in downgrade slopes.

Crawler-Mounted Mobile Loaders.-- At present, Joy loaders and shuttle cars are in favor in the coal mines. Their power consumption and initial costs are higher than the shakers, but their greater speed and productivity makes them as economical as shakers. However, the rooms that are driven with mobile loaders make an angle of 35 to 60 degrees

instead of 90 degrees, thus leaving a diamond-shaped pillar with sharp corners. These sharp corners have a tendency towards crushing, thus creating a serious problem.

Continuous Mining.-- Among the mines visited, only the Sunnyside Mine of Utah Fuel Company employs one continuous miner. This machine was introduced in the late fall of 1949 and has been experimented with ever since.

Because this machine eliminates face preparation and has a high output, it has some very promising features to offer the coal mining industry. However, certain operational problems remain to be solved. These problems are:

(1) Quick transportation of the coal from the continuous miner to the tipple. Two cars are used with the continuous miner, one surge bin car (right behind), the other a standard shuttle car for transporting the coal. As the face advance and the distances increase, the shuttle cars cannot keep up with the continuous miner.

(2) Since the advancement is very rapid, the rate of gas liberation is increased. The present ventilation system should be improved to provide the required amount of air.

(3) The miner produces much dust and fine coal, posing a real problem.

(4) About 10-15 gallons of spray water per minute is necessary. The spray and the flying coal particles

make the coal face invisible. As a result, the operator has a hard time staying within the cutting limits.

(5) The cutting bits of the machine wear out too soon and require too much time to change.

(6) In loading, the miner does not clean the face too well; thus, some hand shoveling is required.

After these problems are solved, the continuous miner will start a new era in the coal mining industry with the following advantages:

(1) Drilling, cutting and blasting are eliminated, as well as the respective machines and men needed for them.

(2) A continuous mining operation can be insured, with high speed and productivity.

(3) Its operation requires only 6 men, an operator, a helper or cleaner, a mechanic, a shuttle car driver, a surge bin operator, and one man on the belt.

Pillar Extracting Methods.-- The common methods of extracting pillars in the districts studied are: (1) open-end, (2) pocket-and-stump, and (3) splitting or a modification of it.

The open-end and the pocket-and-stump methods are very similar in general principles; they differ in the system of supporting the roof along the rib line. In the former, the pocket is open on the goaf side and the roof is supported with timbers. In pocket-and-stump method a narrow pillar of coal (stump) is left along the goaf side to support the roof while driving the pocket. As a result the open-end method

gives a higher recovery rate than the pocket-and-stump. But the pocket-and-stump method is safer.

The splitting method, as described previously with the respective mines, gives the lowest recovery rate of all. The Sunnyside Mine uses a modification of the splitting method that gives a little higher recovery rate than the ordinary system.

In order to establish a safe and economic pillar recovery, the following should be taken into consideration:

(1) Proper extracting method should be used and carried on systematically.

(2) The best size of pillar should be determined.

(3) Right length of rib line should be maintained.

(4) Suitable break line should be chosen.

(5) Complete recovery of coal should be obtained if possible.

Face Preparation.-- The preparation of the face is as important as any other phase in mining the coal. Improper face preparation nullifies the efforts of machines and crews to maintain high efficiency of operations.

The face preparation may consist of the following stages: (1) cutting, (2) drilling, and (3) shooting. The coal is very seldom shot on the solid. Undercutting is the predominant method now used in preparing coal faces. The reason for undercutting is that it gives better breakage of the face, limits height of face and gives excellent conditions for

trackless mining. Top cutting is employed to leave a layer of coal to help support the bad roof, or to eliminate an impure band near top of seam. Shear cutting may be practiced to release the coal burden and to make blasting easier. This is done either at the center or at both sides of the face. Side shearing also serves to limit the shape of the entry driven.

Drilling order changes with the thickness of seam, bed condition and the type or character of coal. Undercut coal faces are shot with top holes and center "breaker." The rib holes give an arching effect and support the top coal. These rib holes are usually drilled parallel to the ribs. Breaker holes are sometimes angled toward the center. The top holes are drilled parallel to the roof if blasted with explosives; when cardox is used, the top holes are dropped a little and angled upwards, e.g. Imperial and Eagle mines. The depth of the holes are 6 inches shorter than the cuts, to avoid shooting on the solid, and ranges from 6 to 8.5-ft. for shakers and mobile loaders, respectively.

In shooting the coal, permissible sheathed explosives are used in all the mines studied. Only Imperial and Eagle mines use cardox for blasting the coal when large lumps are needed, according to the market demand. To meet the U.S. Bureau of Mines regulations, every hole after being charged is stemmed.

Transportation.-- The system of transportation in the

districts studied are: (1) a combination of rope- and track-haulage, (2) track-haulage and shaft hoisting, and (3) track-haulage, rope-haulage and belt conveyors.

Direct-current, trolley locomotives are used in the main entries with track-haulage. In strike or cross entries either cable reel or the storage battery locomotives are employed for gathering purposes. As far as safety is concerned, only the permissible type of storage battery locomotives will not cause a fire or explosion. But the main objection to this type is that it is not powerful enough to use on the main lines. For gathering purposes its power is sufficient, but it requires charging station, and its frequency of charging is a nuisance.

Since the main haulage road serves also as the main air intake, it lessens the danger of a fire hazard from that respect. With the introduction of large capacity mine cars and suitable safety devices, track-haulage on the main entries is quite satisfactory when a coordinated, smooth running system is established all over the mine.

The belt conveyor system is gaining favor in use. Today some mines are using belt conveyors advantageously even in cross entries and rooms, as well as on the main slopes. The main objection to the belt conveyors is the high initial cost and its heating effect that may lead to a fire or explosion. With a high degree of precaution and careful dust handling, the danger of fire may be overcome. The high initial cost may be partly cancelled by eliminating the number of cars

needed (when a trackless mine is established) and by its higher efficiency. Furthermore, it is claimed that tracks in the temporary entries can seldom be relaid more than twice. The life of a belt is much greater. A final outstanding feature in favor of the belt conveyor is that it seems to be the unique transportation system that may complete the cycle of the continuous mining operation.